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RESEARCH ARTICLE

The potential of gardening and other plant-related interventions to reduce symptoms of depression: A systematic review of non-randomized controlled trials and uncontrolled studies

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Abstract

1. Previous systematic reviews have examined the effect of horticultural interventions (e.g., taking care of plants, planting, gardening) on individuals' depressive symptoms through analyses focused exclusively on randomized controlled trials, but that approach overlooks a majority of the potentially informative published research.
2. To complement previous work, we searched the databases MEDLINE, PsycArticles, SCOPUS, Google Scholar, and ClinicalTrials.gov and identified 30 non-RCTs ($n = 1063$ participants; all adults) and 32 uncontrolled studies ($n = 517$ participants; only one study included 6 young people) examining the effects of horticultural interventions on depression.
3. Using random effects meta-analysis, we discovered the evidence from these studies largely supports findings from RCTs. Like the RCTs, the non-RCTs indicate that some horticultural interventions combined with usual care (i.e., continuing normal routine for healthy people or conventional treatment for unhealthy ones) may reduce depressive symptoms more than usual care alone, with most studies finding a moderate (Hedges' $g \geq 0.5$) or large effect ($g \geq 0.8$). We also found that participants might adhere similarly well or even better to horticultural interventions than to usual care alone, and no adverse events were reported. Twenty-five of the 32 uncontrolled studies reported pre and post-intervention mean depression scores. Of these 25 studies, 24 reported an improvement in mean depression scores and, in 16 of them, the improvement was greater than

20%. All studies present some risk of bias due to design limitations, but no evidence of publication bias was detected.
4. Our findings support assertions that some horticultural interventions are effective and safe as a complementary strategy to reduce adults' depressive symptoms. More research is needed to understand how specific participant and intervention characteristics can influence the success of horticultural interventions on depressive symptoms.

KEYWORDS
complementary intervention, complex intervention, depression, gardening, horticultural therapy, therapeutic horticulture

1 | INTRODUCTION

Depression is a serious global health challenge that can harm different dimensions of people's lives including professional achievement, affective relationships, and overall health and well-being (Bernaras et al., 2019; Cipriani et al., 2018; Fried et al., 2022), and the prevalence of this disorder has increased since the start of the COVID-19 pandemic (World Health Organization, 2022). Psychotherapy and the use of antidepressants are two of the most well-known and recommended treatments for depression (Lopresti, 2019). Although effective, research suggests that combining mainstream treatments with complementary activities may improve depressive symptoms more than mainstream treatments alone (Cuijpers et al., 2020; Lopresti, 2019; McCormack & Korownyk, 2018). Thus, efforts have concentrated on complementary interventions that may help to provide greater reductions in depressive symptoms, such as dietary changes (Berk & Jacka, 2019), physical exercise (Catalan-Matamoros et al., 2016), and contact with nature (Rosa et al., 2021). The use of nature-based activities to reduce people's depressive symptoms seems especially promising (Rosa et al., 2021) and is the focus of this paper. The health benefits associated with nature-based activities could be explained by several theoretical frameworks (Fernee et al., 2017; Houge Mackenzie et al., 2021; Kaplan & Kaplan, 1989; Rosa et al., 2024; Ulrich et al., 1991; Wilson, 1984). For example, Attention Restoration Theory posits exposure to nature helps restore the ability to direct attention to specific tasks (Kaplan, 1995). This would, in turn, increase the individual's ability to concentrate. Given that difficulty in concentrating is a symptom of Major Depressive Disorder (MDD; American Psychiatric Association, 2014), improved concentration might explain why natural exposure diminishes depressive symptomatology. From a different perspective, Stress Recovery Theory posits that contact with non-threatening natural environments promotes stress reduction and improved mood (Ulrich et al., 1991), both of which are closely related to MDD (American Psychiatric Association, 2014). In addition to these two theoretical frameworks, the biophilia hypothesis proposes that people have an innate emotional affiliation with nature (Kellert & Wilson, 1993) that is reinforced through contact with elements of the natural world (Rosa & Collado, 2019, 2020; Šorytė et al., 2023). These experiences are likely to be pleasurable and may combat anhedonia, another key symptom of depression (American Psychiatric Association, 2014; Rosa, 2024). In addition to these theory-based explanations, activities in nature commonly involve physical activity (Singh et al., 2023) and socialization (Hartig, 2021), which are also associated with improvement in depressive symptoms. Not surprisingly, studies suggest that activities in nature may improve depressive symptoms such as difficulty concentrating (Clatworthy et al., 2013), sad mood (Soga et al., 2017), sleep problems (Shin et al., 2012), and hopelessness (Sturm et al., 2012). What remains uncertain, however, is what types of nature exposure, and how much of it, might be required to generate these health benefits.

Nature-based interventions can take many forms. In the academic literature, three different types are often described: nature-based adventure (e.g., Sturm et al., 2012), forest therapy (e.g., Kim et al., 2009), and horticultural activities (e.g., Kam & Siu, 2010). In this study, we focus on the latter. Nature-based adventure is a specific type of nature-based activity involving significant risk, challenge, and novelty (Rosa, Chaves, Collado, Larson, & Profice, 2023). The term forest therapy refers to a combination of therapeutic activities (e.g., mindfulness) provided in a forested area (Rosa et al., 2021). Horticulture relates to "the art and science of growing flowers, fruits, vegetables, and trees and shrubs" (Mizuno-Matsumoto et al., 2008, p. 170). Horticultural interventions refer to the participation in horticultural activities facilitated by a horticultural therapist or other trained professional to achieve health benefits (American Horticultural Therapy Association, 2017; Soga et al., 2017). In one example, Lin et al. (2020) provided institutionalized older adults with activities like arranging flowers and plant reproduction, and these were led by two certified horticultural therapists. Participants were involved in these activities 1 h a day (i.e., duration), twice a week (i.e., frequency), during 9 weeks (i.e., length), but these intervention characteristics have been highly variable across studies (e.g., Fan et al., 2021; Shin et al., 2016).

Several systematic reviews have synthesized the evidence from randomized and non-randomized studies assessing the effects of forest therapy (Rosa et al., 2021) and nature-based adventure on

depression (Rosa, Chaves, Collado, Larson, & Profice, 2023), generally highlighting positive effects but to variable degrees. Moreover, a recent systematic review summarized the findings of randomized controlled trials (RCTs) involving horticultural interventions (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023). This review largely supported the idea that horticultural interventions coupled with usual care can reduce adults' depressive symptoms more than usual care alone, with most studies suggesting a moderate (Hedges' $g \geq 0.5$) or large ($g \geq 0.8$) effect size. This review also indicated that participants adhere relatively well to horticultural interventions (i.e., low dropout rates) and that adverse events (e.g., feeling fatigued after the intervention) are rare.

One limitation of Rosa, Chaves, Collado, Larson, Lee, and Profice's (2023) systematic review is that none of the included RCTs assessed how the effect of horticultural interventions varied depending on participant characteristics (e.g., severe vs. mild depression) and intervention characteristics like length or frequency and duration. A better understanding of if and how the effects of horticultural interventions on depressive symptoms vary according to these characteristics is essential to the design of future horticultural interventions. Another limitation of Rosa, Chaves, Collado, Larson, Lee, and Profice's (2023) systematic review was that all RCTs focused on adults. Thus, even though the prevalence of major depression in children and adolescents is increasing (Selph & McDonagh, 2019), no conclusions about the effect of horticultural interventions on the depressive symptomatology of children and adolescents could be drawn. Finally, all RCTs included in this previous review were published in peer-reviewed journals, so it was not possible to examine the difference in estimates between published and unpublished studies.

In this paper, we build on previous research to present a systematic review summarizing the results of non-RCTs (i.e., experimental trials without randomization) and uncontrolled studies (i.e., one-group, pre-post) that assessed the effects of horticultural interventions on depressive symptoms as registered by commonly-used depression outcome measures. The aims of this systematic review of non-RCTs and uncontrolled studies were to (1) examine whether the results reported in RCTs are similar to the findings of non-RCTs and uncontrolled studies; (2) explore whether participant and intervention characteristics influence the effect of horticultural interventions; (3) evaluate the effects of horticultural interventions on young people's depressive symptoms (4) check potential publication bias; and, (5) evaluate the adherence to and possible adverse events reported in non-RCTs and uncontrolled studies during horticultural interventions. Similar to the goal of the previous review paper focused on RCTs (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023), the overarching research question guiding our review was: What is the effect of horticultural interventions on depressive symptoms as compared to alternative interventions (or no intervention)? (see our registered protocol in Data S1).

2 | METHOD

2.1 | Eligibility criteria

The criteria for inclusion in our review are summarized in Table 1, and a detailed description of these criteria can be found in our registered protocol (Data S1), which was grounded on the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement (Shamseer et al., 2015). We did not exclude studies based on date, language, or because they were not published in a peer-reviewed journal.

In this study, we focus on non-RCTs and uncontrolled studies using the same literature search protocols as those described in the previously published review paper focused on RCTs (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023). That search protocol is described below.

2.2 | Search strategy

We used previous systematic reviews on associated topics (e.g., the effect of therapeutic gardens on people with dementia) as an informative source to find eligible primary studies (e.g., Murroni et al., 2021; Nicholas et al., 2019), and we searched for primary

TABLE 1 Eligibility criteria for our review based on population (P), intervention (I), comparison groups of interest (C), outcomes (O), and study designs (S).

PICOS	Description
Population	Studies with humans at any age, healthy or unhealthy
Intervention	Studies that provide or consider any form of horticultural intervention
Comparison groups of interest	Studies with any comparison/control group and studies without a control group
Outcomes	Studies that assess depression using a measure designed to measure depression. At least one study (i.e., a validation study) should exist describing how the content of the measure matches the construct's content (i.e., depression)
Study design[a]	Randomized and non-randomized studies of interventions

[a]It was part of our eligibility criteria to include both randomized and non-randomized studies of interventions. In this manuscript, we focus on non-randomized controlled trials (non-RCTs). The findings from randomized studies were reported in a separate study.

studies that were not included in these systematic reviews. On January 19 of 2022 the databases PsycArticles (APA), MEDLINE (PubMed), SCOPUS (Elsevier), Google Scholar, and ClinicalTrails.gov were searched from inception. In addition, we checked the references of included studies and our personal files (e.g., computer archives), which could provide access to additional studies. Our exact search strategy is described in Table 2.

2.3 | Selection, data extraction, and risk of bias assessment

The first author performed the title and abstract screening, selection based on full-text, data extraction, and (informally) risk of bias assessment. The second author checked whether the eligibility criteria were applied appropriately. Specifically, the second author read through the decisions made by the first author and approved/disapproved them. The few disagreements between the first author and the second author were resolved through discussion. From each study, we collected information concerning participants' sociodemographic variables, the setting where the interventions took place, the horticultural activities conducted, and the depression score at baseline and after the intervention (see table 2 in Data S1). We planned to assess the risk of bias from non-RCTs with the ROBINS-I tool (Sterne et al., 2016). Nonetheless, it was not feasible due to a lack of resources (e.g., time). Whereas we do not assess the risk of bias formally, we discuss the limitations inherent to non-RCTs and uncontrolled studies of horticultural interventions and some additional limitations that these studies might have (e.g., lack of a registered analysis plan).

2.4 | Data synthesis

To estimate the effect of horticultural interventions on depressive symptoms, we extracted data from the pre-test closest to the beginning of the intervention and the post-test closest to the end of the intervention. When studies used more than one depression outcome measure, we selected only one measure based on pre-specified criteria (see "Dealing with Multiple Effect Estimates" in

TABLE 2 Complete search strategy for the literature review, according to database.

PubMed	
1	"Horticultural Therapy"[Mesh]
2	"horticultural therapy" [tiab] OR "horticultural activit*" [tiab] OR "therapeutic horticulture" [tiab] OR "gardening therapy" [tiab]
3	"Depression"[MeSH] OR "Depressive Disorder"[MeSH]
4	depress* [tiab] OR dysthymi* [tiab] OR adjustment disorder* [tiab] OR mood disorder* [tiab] OR "affective disorder" [tiab] OR "affective symptoms" [tiab]
5	(#1 OR #2)
6	(#3 OR #4)
7	(#5 AND #6)
8	#7 NOT review[Publication Type]
PsycINFO (APAPsycNet)	
1	Index Term: Horticulture Therapy
2	{Depression (Emotion)} OR {Beck Depression Inventory} OR {Atypical Depression} OR {Major Depression} OR {Zungs Self Rating Depression Scale}
3	"horticultural therapy" OR "horticultural activit*" OR "therapeutic horticulture" OR "gardening therapy"
4	depress* OR dysthymi* OR "adjustment disorder*" OR "mood disorder*" OR "affective disorder" OR "affective symptoms"
5	(#1 OR #3)
6	(#2 OR #4)
7	(#5 AND #6)
SCOPUS (Elsevier)	
1	("horticultural therapy" OR "horticultural activit*" OR "therapeutic horticulture" OR "gardening therapy") AND (depress* OR dysthymi* OR "adjustment disorder*" OR "mood disorder*" OR "affective disorder" OR "affective symptoms")
2	Limited to Article, Conference Paper, and Book Chapters
3	Search limited to article Title, Abstract, Keywords
Google Scholar	
1	allintitle: depressive "horticultural therapy" OR "horticultural activit*" OR "therapeutic horticulture" OR "gardening therapy"
2	allintitle: depression "horticultural therapy" OR "horticultural activit*" OR "therapeutic horticulture" OR "gardening therapy"
Clinicaltrials.gov (https://clinicaltrials.gov/)	
1	("horticultural therapy" OR "Therapeutic horticulture") AND (depression OR depressive)*

Data S1). When feasible, we calculated Hedges' *g* using each group's mean change in depression scores from pre to post-intervention and its standard deviation. Focusing on change in depressive symptoms is more appropriate than the difference between groups in post-intervention measurements when group scores differ substantially at baseline (Vickers, 2001). Otherwise, we calculated Hedges' *g* by using the post-test scores and its standard deviation (Higgins et al., 2019).

The number of participants who demonstrated substantial improvement following the intervention was another relevant outcome. We operationalized response to the intervention as a ≥50% decrease in depressive symptoms from baseline (Riedel et al., 2010). Research shows that a ≥50% decrease is a good proxy for clinically relevant improvement in depression as evaluated by three depression scales: Hamilton Depression Rating Scale (HDRS), Beck Depression Inventory (BDI), and Montgomery Asberg Depression Rating Scale (MADRS) (Riedel et al., 2010). Hence, we calculated the number of participants reporting a ≥50% decrease in depressive symptoms when the studies used one of these three scales. This number was calculated using the formula described by Furukawa et al. (2005). In addition, for all studies with available data, we report the number of participants who dropped out and the adverse events that occurred. When feasible, we calculated risk ratios for dichotomous outcomes as these are easier to understand than odds ratios (Higgins et al., 2019).

We conducted a random effects meta-analysis because this analysis incorporates the statistical heterogeneity among studies in the confidence interval and we ran sensitivity analyses to check the robustness of our findings (Higgins et al., 2019). In this meta-analysis, we also assessed whether the results from studies that offered other interventions (co-interventions) in addition to horticulture revealed greater improvements in people's depressive symptoms than studies that just involved horticultural interventions. When there were multiple reports (e.g., published papers) based on the same sample of participants, we used the reports to describe the sample but the unique sample was only considered as one study. To illustrate, we considered Gonzalez et al.'s (2009, 2010, 2011a, 2011b) multiple reports as two studies because they are based on two unique samples, which are both described by Gonzalez et al. (2011a).

Because no study reported having substituted participants' usual treatment with horticultural activities, we assumed that the horticultural interventions were used as complementary interventions for unhealthy participants. We used the term "usual care" to represent individuals' keeping their normal routine: unhealthy participants continuing with their conventional treatment (e.g., psychotherapy), and the healthy ones receiving no intervention. We use Kim et al.'s (2016) study as an example to clarify the distinction between usual care and co-interventions. This study was conducted with patients with Alzheimer at Seongdong-gu Center for Dementia. Usual care, in this case, is the normal care offered to patients at this centre and co-interventions are the additional interventions (e.g., exercise and music therapy), other than horticulture, provided to the study's participants by the study team.

To facilitate the interpretation of the findings from the non-RCTs included in this systematic review, we report estimates of effects and, when feasible, 95% confidence intervals (CI) for these estimates. Hedges' *g* and risk ratios were calculated using RevMan (Review Manager (RevMan) [Computer Program], 2020). All data utilized in our analyses that are not reported in the manuscript are available in Data S2 (https://osf.io/ta69c), with a more detailed description of included studies in Data S3. These files also contain the reference information for all the studies included in our systematic review.

3 | RESULTS

Our database searches produced 223 records, from which 62 were deemed eligible after the full-text assessment. As an instance of a study excluded after the full-text assessment, Shao et al.'s (2020) study was excluded because it did not assess people's depression using a depression outcome measure. An additional 20 studies were identified through supplementary search strategies such as checking the reference list of all eligible studies and previous systematic reviews on associated topics (e.g., Nicholas et al., 2019; Soga et al., 2017). Thus, a total of 82 studies were deemed eligible based on our eligibility criteria (Table 1). Of these 82 eligible studies, 30 were non-RCTs and 32 were uncontrolled studies (see Figure 1 for a flow diagram). The other 20 were all RCTs analysed in a separate review paper (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023). Thus, 62 studies are summarized in this systematic review.

These 62 studies took place in 10 different countries and involved a total of 1580 participants (Table 3). Forty-nine studies took place in Asia and the Middle East (South Korea, Japan, Taiwan, Israel, and Lebanon), eight in the United States, and five in Europe (Norway, Switzerland, Romania, United Kingdom). Fifty-six studies were published in peer-reviewed scientific journals between 2001 and 2021. The six unpublished studies included a preprint (Fan et al., 2021), a Ph.D. dissertation (Ascencio, 2020), a Master's thesis (Penman, 2015), and three symposium papers (Lee et al., 2008; Park, Shoemaker, et al., 2015; Son et al., 2004). These studies focused on a range of populations including older adults in various settings (e.g., nursing homes and psychiatric clinics), adults with mental health problems such as depression, women with fibromyalgia, women immigrants, battered women, women refugees, women with hearing impairment, mothers, stroke patients, patients with cancer, people who served the Armed Forces, young people with disability, workers with hearing disability, people with visual impairment, and prisoners (Table 3). Characteristics of the interventions also varied (Table 4). These interventions included a variety of horticultural activities such as flower arrangement, seeding, transplanting a plant, making a terrarium, pruning, watering plants, and harvesting. Intervention length varied from 2 weeks to more than 51 weeks. The frequency of horticultural interventions ranged from weekly to almost daily sessions, and the duration of each session from half an hour to three hours.

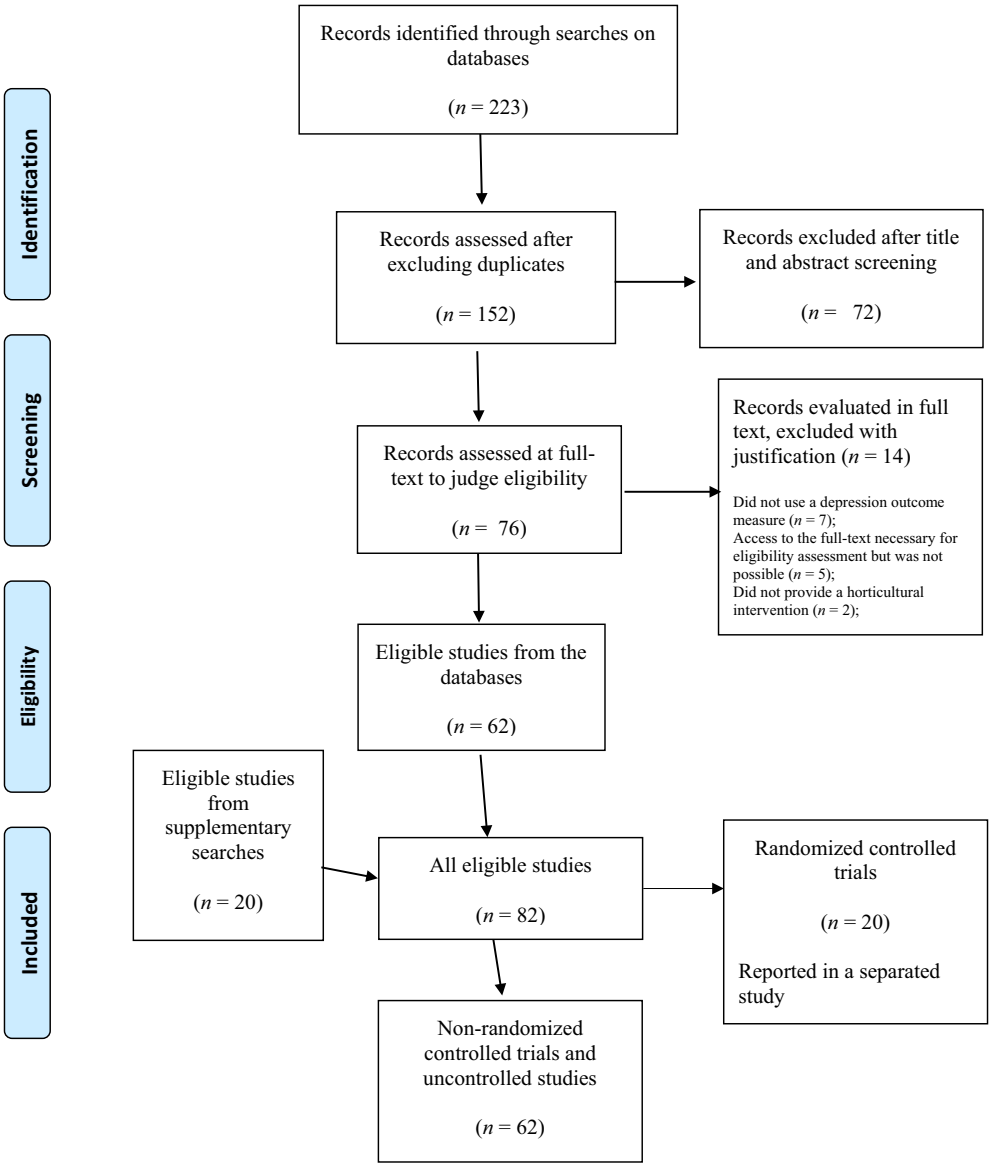

FIGURE 1 Flowchart illustrating the process of identifying and selecting studies.

Some horticultural interventions (e.g., Fan et al., 2021; Korah et al., 2021) were associated with other interventions (i.e., co-interventions) beyond usual care such as psychological therapy, music therapy, art therapy, occupational activities, Stress Immunization Training, activities using 3D virtual reality, and activities in contact with nature other than horticulture. The effects of horticultural interventions were most often compared with usual care. Different comparisons than usual care included comparing a longer with a shorter horticultural intervention and comparing the same intervention provided to individuals with different depression severity. Additionally, one study (Kim et al., 2010) compared horticultural interventions plus some occupational activities with just engaging in these occupational activities. Thirteen different measures were used to assess depression. The short form (15 items) version of the Geriatric Depression Scale was the most frequently used measure followed by the original Geriatric Depression Scale (30 items) and by the Beck Depression Inventory (Tables 3 and 4 and tables 1 and 2 in Data S2).

3.1 | Horticultural intervention versus usual care alone

From the 30 non-RCTs included in this systematic review ($n = 1063$ participants; all adults), 27 compared horticultural interventions combined with usual care to usual care alone. Across many studies in our analysis, people received usual care for health conditions such as MDD, dementia, stroke, cancer, and musculoskeletal pain so, often, usual care involved some intervention (Table 4). From these 27 studies, 24 trials reported the post-test mean and its standard deviation, and only two also reported the mean change from baseline to post-intervention and its standard deviation, which is

TABLE 3 Main characteristics of the non-randomized controlled trials (non-RCTs) included in this systematic review of studies investigating the effects of horticultural interventions on depressive symptoms.

Study	Participants	Mean age or age range	Women %	Time (T) in which data was collected[a]	Depression measure	Country	Setting where the horticultural intervention took place
Fan et al. (2021)	Community-dwelling Older Adults	70.4	NI	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale-15	Taiwan	Two community long-term care facilities
Korah et al. (2021)	Adults diagnosed with Major Depressive Disorder	19 to 84	64.3	T1: At admission T2: After two weeks or before discharge	Beck Depression Inventory	United States of America	Inpatient units of a university hospital psychiatry department and in the in-campus horticulture facility
Lin et al. (2020)	Institutionalized older adults	77.9	NI	T1: At baseline T2: After the intervention	Geriatric Depression Scale-15	Taiwan	One long-term care facility (>300 beds) for the experimental and another similar for the control group
Kim et al. (2020)	Elderly women with mild cognitive impairment and mild dementia	81.8	100	T1 = Before the intervention T2: After the intervention	Geriatric Depression Scale-15	South Korea	A health center located in H-gun, Gyeongsangnam-do
Yavne et al. (2019)	Adult women diagnosed with fibromyalgia	51	100	T1: Before the intervention T2: After the intervention	Hamilton Depression Rating Scale	Israel	NI
Lee et al. (2018)	Stroke patients	54.7	48.4	T1: One week before the intervention T2: One week after the intervention	Geriatric Depression Scale-15	South Korea	A height-adjustable table (4.6×1.5 m) and a garden plot (18×4.5×0.3 m) were installed in an occupational therapy room and rooftop garden of a hospital
Yoon and Sung (2017)	Older patients with mild dementia	NI	93.3	T1: Before the intervention T2: Immediately after the intervention	Geriatric Depression Scale	South Korea	The experimental group was a nursing home and the control group was a senior nursing hospital
Kelley et al. (2017)	Students who served in the United States Armed Forces	21 to 53	23.8	T1: Before the intervention T2: At the conclusion of the intervention	Depression Anxiety Stress Scales	United States of America	Greenhouse at the Texas State University
Park and Jung (2017)	Female marriage immigrants	41.5	100	T1: Before the intervention T2: After the intervention	Beck Depression Inventory	South Korea	At a social welfare center
Park et al. (2016)	Elderly women at community centers	82.1	100	T1: Before the intervention T2: At the completion of the intervention	Geriatric Depression Scale-15	South Korea	A garden plot (8.0 · 5.1 m) was installed in the front yard of a senior community center
Penman (2015)	Healthy adult woman	37	100	T1: Before the intervention T2: After the intervention	Beck Depression Inventory-II	United States of America	A greenhouse located on the medical campus of the University of Florida

(Continues)

TABLE 3 (Continued)

First author (year)	Participants	Mean age or age range	Women %	Time (T) in which data was collected[a]	Depression measure	Country	Setting where the horticultural intervention took place
Park, Lee, et al. (2015)	Stroke patients	65.7	61.5	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	This program was conducted in an indoor horticultural treatment room. Participants sat around a desk and performed horticultural activities
Masuya et al. (2014)	Elderly people living in nursing homes	85.5	87.5	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale-15	Japan	NI
Lee et al. (2014)	Female adult prisoners	48.1	100	T1: Before the intervention T2: After the intervention	Depression subscale of the Symptom Checklist-90	South Korea	At the prison
Lee et al. (2013)	Male adult prisoners scheduled to be released	NI	0	T1: Before the intervention T2: After the intervention	Depression subscale of the Symptom Checklist-90	South Korea	NI
Verra et al. (2012)	Patients with chronic musculoskeletal pain	48.0	NI	T1: Before the intervention T2: After the intervention	Hospital Anxiety Depression Scale	Switzerland	The rehabilitation clinic (RehaClinic) in Bad Zurzach
Kwon et al. (2011)	Patients with terminal cancer	57.7	38.7	T1: At the beginning of the intervention T2: Two days after the intervention	Zung Self-Rating Depression Scale	South Korea	Indoors and outdoors
Song et al. (2010)	Depressed patients at a psychiatric clinic	NI	80	T1: Before the intervention T2: After the intervention	Beck Depression Inventory	South Korea	At a psychiatric clinic
Kang et al. (2010)	Older adults qualified as cognitively handicapped	≥ 65	89.5	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	NI
Kim et al. (2010)	Patients with hemiplegia after stroke	62	35	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	Indoor
Lee et al. (2010)[b]	Internationally married migrant women	36.6	100	T1: Before the intervention T2: After the intervention	Center for Epidemiologic Studies Depression Scale	South Korea	Unclear
Yoo and Jeong (2010)[b]	Older adults in facilities	Unclear	Unclear	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	Unclear
Han et al. (2009)[b] trial 1	Older adults without Alzheimer	Unclear	Unclear	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	Unclear

TABLE 3 (Continued)

First author (year)	Participants	Mean age or age range	Women %	Time (T) in which data was collected[a]	Depression measure	Country	Setting where the horticultural intervention took place
Han et al. (2009)[b] trial 2	Older adults with Alzheimer	Unclear	Unclear	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	Unclear
Lee et al. (2008)	Women who were battered and were at a shelter	NI	100	T1: Before the intervention T2: After the intervention	Zung Self-Rating Depression Scale	South Korea	NI
Hwang et al. (2007)[b]	Mothers of children who went to an elementary school	Unclear	100	T1: Before the intervention T2: After the intervention	Zung Self-Rating Depression Scale	South Korea	NI
Kim et al. (2006)	Patients with cancer or an incurable disease close to death	NI	32.8	T1: Before the intervention T2: After the intervention	Zung Self-Rating Depression Scale	South Korea	Indoors and outdoors
Son et al. (2004)	Patients with chronic schizophrenia	NI	NI	T1: Before the intervention T2: After the intervention	Depression subscale of the Symptom Checklist-90	South Korea	Indoors using tables and outdoors
Yun and Kim (2003)[b]	Older depressed adults	71.8	62.5	T1: Before the intervention T2: After the intervention	Geriatric Depression Scale	South Korea	Unclear
Jeung et al. (2001)	Psychiatric patients	41.8	50	T1: Before the intervention T2: After the intervention	Beck Depression Inventory	South Korea	At a mental health center

Abbreviation: NI, no information.

[a]Only the times utilized in our analyses are reported here.

[b]We were unable to translated the full text of this paper.

TABLE 4 Description of horticultural activities, comparison group activities, and co-interventions of the non-randomized controlled trials (non-RCTs) included in the systematic review.

Study	Horticultural interventions[a] and comparison group activities	Co-interventions	Intervention length in weeks[b]	Intervention frequency (how many times a week)[c]	Session duration in hours[d]	Group *N*
Fan et al. (2021)	Horticultural intervention: Hands-on horticultural activities; using plants to make designed products.	Activities using 3D virtual reality and group talk	8	1	2	32
	Usual care: The participants received scheduled activities, such as physical fitness and paper cutting, without any gardening activities during the intervention and follow-up period.	Not applicable	Not applicable	Not applicable	Not applicable	30
Korah et al. (2021)	Horticultural intervention: Study participants took part in plant propagation, cultivation, and maintenance, as well as in extensions of those activities such as sensory interactions, horticulture education, and plant crafts.	Both intervention and control groups received standardized pharmacological as well as electroconvulsive therapy treatments during the study	2	2	1	25
	Usual care: Pharmacological treatment and electroconvulsive therapy	Not applicable	Not applicable	Not applicable	Not applicable	27
Lin et al. (2020)	Horticultural intervention: Activities included plant familiarization, contact with plants, arranging flowers, and plant reproduction.	Activities using 3D virtual reality and activities to build relations among participants	9	2	1	59
	Usual care: Members of this group did not participate in any similar program during the intervention and follow-up periods.	Not applicable	Not applicable	Not applicable	Not applicable	47
Kim et al. (2020)	Horticultural intervention (15 weeks): Activities included doing grass dolls, flower arrangements, sowing, and harvesting.	Cognitive and socialization activities	15	1	1.67	13
	Horticultural intervention (7 and a half weeks): Same activities as the longer intervention.	Cognitive and socialization activities	7.5	2	1.67	8

TABLE 4 (Continued)

Study	Horticultural interventions[a] and comparison group activities	Co-interventions	Intervention length in weeks[b]	Intervention frequency (how many times a week)[c]	Session duration in hours[d]	Group *N*
Yavne et al. (2019)	Horticultural intervention: Flower design and taking care of flowers.	None reported	12	1	NI	31
	Usual care: Usual care for fibromyalgia.	Not applicable	Not applicable	Not applicable	Not applicable	30
Lee et al. (2018)	Horticultural intervention: Activities included planting, sowing, making garden plots, and making flower garden beds.	As treatment services in the rehabilitation hospital, both groups were equally provided occupational and physical therapy	3	1	1	14
	Usual care: Occupational and physical therapy.	Not applicable	5	1	1	17
Yoon and Sung (2017)	Horticultural intervention: Activities included planting and flower decoration.	None reported	6	2	1	15
	Usual care: Usual care for people with dementia.	Not applicable	Not applicable	Not applicable	Not applicable	15
Kelley et al. (2017)	Horticultural intervention: Activities included growing succulents in hypertufas, plant propagation, caring for indoor plants, and potting.	None reported	6	1	1	8
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	9
Park and Jung (2017)	Horticultural intervention: Activities included planting, flower arrangement, and making plants topiary.	Rational Emotive Behaviour Therapy	10	1	2	7
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	7
Park et al. (2016)	Horticultural intervention: The intervention comprised making plant beds, furrows in the plots, planting transplants, garden maintenance (e.g., fertilizing, weeding, watering, harvesting), and other activities such as flower arrangement.	None reported	8.6	2	0.83	24
	Usual care: Usual care for elderly women at a senior community center	Not applicable	Not applicable	Not applicable	Not applicable	26
Penman (2015)	Horticultural intervention: It involved planting, transplanting, and cutting plants.	None reported	6	2	1	12
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	11

(Continues)

TABLE 4 (Continued)

First author (year)	Horticultural interventions[a] and comparison group activities	Co-interventions	Intervention length in weeks[b]	Intervention frequency (how many times a week)[c]	Session duration in hours[d]	Group *N*
Park, Lee, et al. (2015)	Horticultural intervention: The intervention included planting, flower arrangement, sowing, and making a grass doll.	Stress Immunization Training	8	2	0.67	13
	Usual care: Usual care for patients who had a stroke.	Not applicable	Not applicable	Not applicable	Not applicable	13
Masuya et al. (2014)	Horticultural intervention: It included taking care of plants, growing vegetables, transplanting, pruning, and harvesting.	None reported	6	1	0.5 to 0.67	9
	Usual care: Usual care for elderly people living in nursing homes.	Not applicable	Not applicable	Not applicable	Not applicable	9
Lee et al. (2014)	Horticultural intervention: The intervention involved seeding, planting, making a compost box, and harvesting.	Activities to help participants to express their feelings	12	1	NI	10
	Usual care: No intervention.	Not applicable	Not applicable	Not applicable	Not applicable	10
Lee et al. (2013)	Horticultural intervention: It involved seeding, planting, making flower baskets, making a compost box, and harvesting.	Activities to help participants to express their feelings	12	1	NI	18
	Usual care: No intervention.	Not applicable	Not applicable	Not applicable	Not applicable	19
Verra et al. (2012)	Horticultural intervention: Working with plants and various elements of gardening.	Pain management program, perception training, and practicing coping strategies	4	2	0.42 to 0.5	37
	Usual care: A pain management program.	Not applicable	Not applicable	Not applicable	Not applicable	42
Kwon et al. (2011)	Horticultural intervention: Activities included corsage making, growing sprouts, pressing flowers, barley flower baskets, and cup decoration flower arrangement.	Activities to help participants to express their feelings	3	6	0.5	30
	Usual care: Usual care for patients with terminal cancer	Not applicable	Not applicable	Not applicable	Not applicable	30
Song et al. (2010)	Horticultural intervention: The intervention involved sowing, making a flower bouquet, transplanting seedlings, and making a flower basket.	None reported	12.9	1	NI	15
	Usual care: Usual care for depressed patients.	Not applicable	Not applicable	Not applicable	Not applicable	15
Kang et al. (2010)	Horticultural intervention: Planting Kalanchoe in a flowerpot.	Warm-up hand exercises, cognitive stimulation training, music therapy, art therapy, and visiting an arboretum.	NI	NI	0.5	20
	Usual care: Usual care for older adults qualified as cognitively handicapped.	Not applicable	Not applicable	Not applicable	Not applicable	18

TABLE 4 (Continued)

First author (year)	Horticultural interventions[a] and comparison group activities	Co-interventions	Intervention length in weeks[b]	Intervention frequency (how many times a week)[c]	Session duration in hours[d]	Group *N*
Kim et al. (2010)	Horticultural intervention: The activities included flower arrangement, making a flower basket, sowing, and planting.	Occupational therapy	12.9	1	NI	20
	Occupational Therapy: Diverse indoor activities aimed at eliciting physical improvements of the patients. The activities were suited to stroke patients sitting posture.	Not applicable	NI	NI	NI	20
Lee et al. (2010)[e]	Horticultural intervention: The intervention included flower arrangement, growing plants under water, planting herbs, trimming, and transferring plants.	Unclear	24	1	Unclear	7
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	6
Yoo and Jeong (2010)[e]	Horticultural intervention: It included making a flower basket, planting, and flower arrangement.	Unclear	14	1	Unclear	6
	Usual care: Usual care for older adults in facilities.	Not applicable	Not applicable	Not applicable	Not applicable	6
Han et al. (2009)[e] trial 1	Horticultural intervention: It involved planting, fertilizing, making a chrysanthemum basket, and harvesting.	Unclear	Unclear	Unclear	Unclear	6
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	6
Han et al. (2009)[e] trial 2	Horticultural intervention: It involved planting, fertilizing, making a chrysanthemum basket, and harvesting.	Unclear	Unclear	Unclear	Unclear	7
	Usual care: Usual care for older adults with dementia.	Not applicable	Not applicable	Not applicable	Not applicable	7
Lee et al. (2008)	Horticultural intervention: The program was composed of a variety of activities including pressing flowers, flower arrangement, herb cuttings, and planting herbs.	None reported	12	2	1	12
	Usual care: Usual care for battered women in a shelter.	Not applicable	Not applicable	Not applicable	Not applicable	12
Hwang et al. (2007)[e]	Horticultural intervention: The intervention included cutting, making flower baskets, and flower arrangements.	Unclear	7	2	Unclear	10
	Usual care: No intervention	Not applicable	Not applicable	Not applicable	Not applicable	14
Kim et al. (2006)	Horticultural intervention: It involved plating, seeding, making a flower basket, collecting plants, and removing weeds.	None reported	3	7	0.5	34
	Usual care: Usual care for patients with cancer or an incurable disease close to death.	Not applicable	Not applicable	Not applicable	Not applicable	33
Son et al. (2004)	Horticultural intervention: Plant growing	None reported	21.4	2	1	25
	Usual care: Usual care for chronic schizophrenia.	Not applicable	Not applicable	Not applicable	Not applicable	25

(Continues)

TABLE 4 (Continued)

First author (year)	Horticultural interventions[a] and comparison group activities	Co-interventions	Intervention length in weeks[b]	Intervention frequency (how many times a week)[c]	Session duration in hours[d]	Group N
Yun and Kim (2003)[e]	Horticultural intervention for patients with severe depression: It included planting and flower arrangement.	Unclear	10	1	Unclear	4
	Same intervention for participants with mild depression: Same as the above.	Unclear	10	1	Unclear	4
Jeung et al. (2001)	Horticultural intervention: The intervention included seeding, transplanting, harvesting, and flower arrangement.	None reported	15	1	1	12
	Usual care: Usual care for psychiatric patients.	Not applicable	Not applicable	Not applicable	Not applicable	12

Abbreviation: NI, no information.

[a]Unhealthy participants probably continued their usual treatment while participating in the horticultural interventions.

[b]Intervention length refers to the duration of the full intervention.

[c]Intervention frequency refers to the frequency of the horticultural activities or comparison group activities.

[d]Session duration refers to the duration of the horticultural activities or comparison group activities provided during each session.

[e]We were unable to translate the full text of these studies.

preferable when there is a substantial difference between groups in the baseline score. The results from these 24 studies are summarized in a forest plot (Figure 2a). Only one study found a higher depression score for the horticultural intervention group than for the usual care group and this difference was very small ($g = 0.06$). The remaining 23 studies suggest that horticultural interventions plus usual care may reduce depressive symptoms more than usual care alone, with 16 studies finding a moderate ($g \geq 0.5$) or large effect ($g \geq 0.8$). Combining all 24 studies' estimates using the inverse variance random effects meta-analysis, we found a Hedges' g of −0.98, CI 95% [−1.31, −0.65], $p < 0.001$, $I^2 = 78\%$, favouring horticultural interventions (Figure 2a).

Studies in which horticultural interventions were just one among other interventions resulted in a smaller combined estimate than the one obtained from studies in which a horticultural intervention was the only reported intervention (Figure 2a). Removing the studies with imputed SDs did not substantially change the results. Moreover, all four unpublished studies favoured horticultural interventions over usual care. Combining the estimates from these unpublished studies through an inverse variance random effects meta-analysis, we found a $g = -1.24$ [−2.26, −0.22], $p < 0.001$, $I^2 = 78\%$.

Five studies provide usable data to calculate the number of participants who had a reduction in depressive symptoms ≥50% (i.e., response to treatment). In four out of the five studies, more participants responded to treatment in the horticultural intervention plus usual care group than in the group that just received usual care. Combining studies' estimates through a Mantel–Haenszel random effects meta-analysis, we found that participants engaging in horticultural interventions were almost five times as likely to respond to treatment than participants who just continued their usual care (Figure 2b, risk ratio = 4.67 [0.85, 25.59], $p = 0.08$, $I^2 = 77\%$). Notably, removing the study with an imputed SD did not substantially change the results.

Only six studies reported the number of participants who dropped out in the horticultural group and the usual care only group (Figure 3). Combining study estimates using a Mantel–Haenszel random effects meta-analysis, we found that dropouts were less likely in the horticultural group than in the usual care only group (risk ratio = 0.37 [0.07, 1.84], $p = 0.22$, $I^2 = 48\%$). No study reported whether adverse events occurred or not.

3.2 | Horticultural interventions versus other interventions than usual care

Only three studies compared horticultural interventions to other interventions than usual care. Kim et al. (2020) tested whether the same horticultural activities provided with a different length and frequency would affect individuals' depressive symptoms differently. Specifically, these authors assigned participants to either 15 weeks of horticultural intervention occurring once a week, or 7½ weeks of the same activities occurring twice a week. The depression mean score of the groups was similar at the end of the intervention ($g = 0.02$ [−0.86, 0.90], $p = 0.96$). In another study,

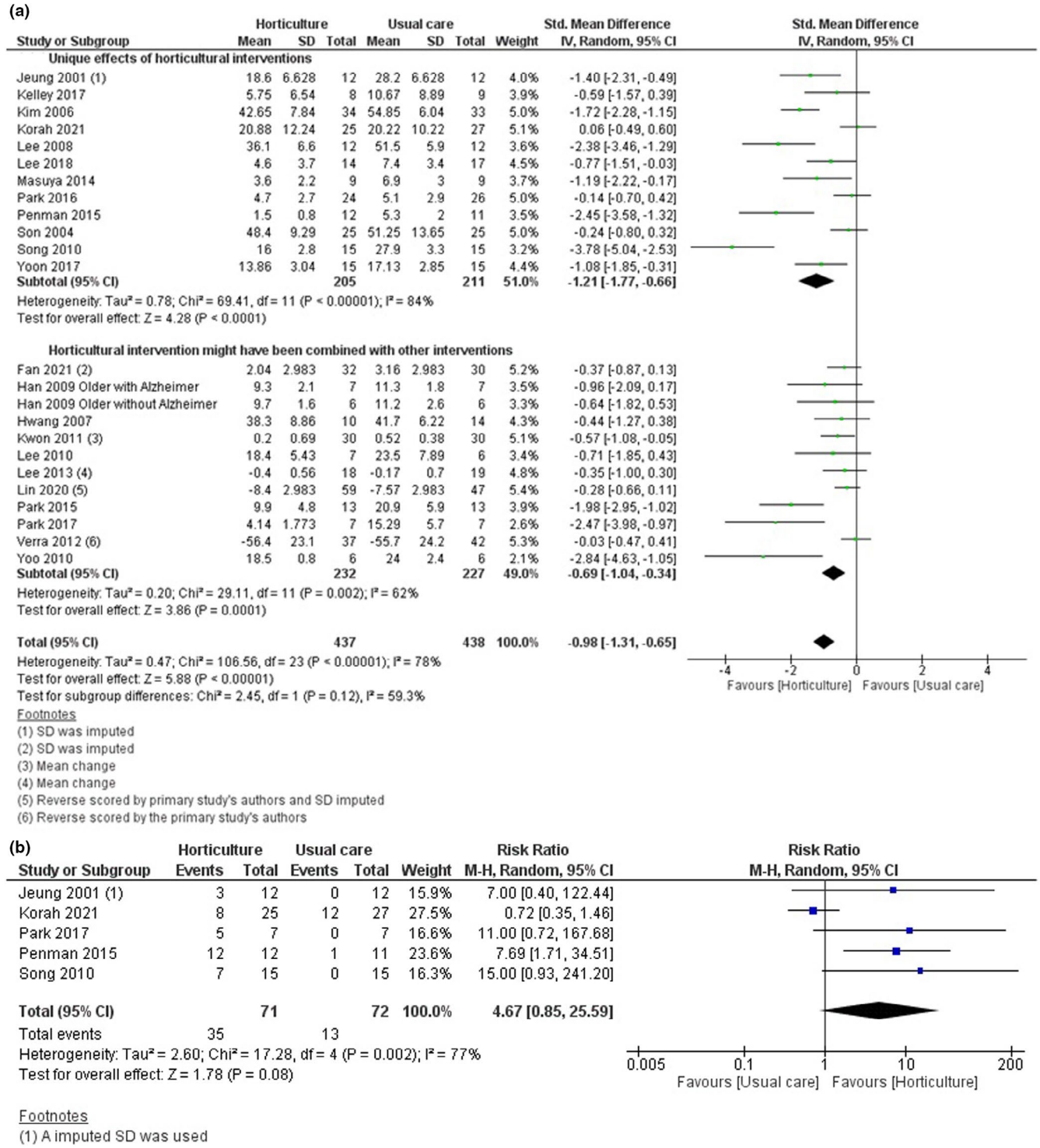

FIGURE 2 (a) Comparison of the post-intervention mean score or mean change from baseline of horticulture groups versus usual care only using the inverse variance random effects meta-analysis. (b) Comparison of the risk of response to treatment (i.e. ≥50% reduction in depressive symptoms) between horticulture groups and usual care groups, using the mantel–haenszel random effects meta-analysis. Events refer to the number of participants who responded to treatment. Green squares refer to standardized mean differences and blues squares to risk ratios. Bigger squares indicate more participants in a study or more events and a bigger diamond indicates greater uncertainty in the combined estimate.

Kim et al. (2010) recruited a sample of stroke patients and tested whether associating horticultural therapy with occupational therapy promoted better psychological benefits than occupational therapy alone. The group who engaged in the horticultural intervention ended the intervention with a lower mean depression score than the occupational therapy only group ($g = -1.21$ [−1.89, −0.53], $p < 0.001$).

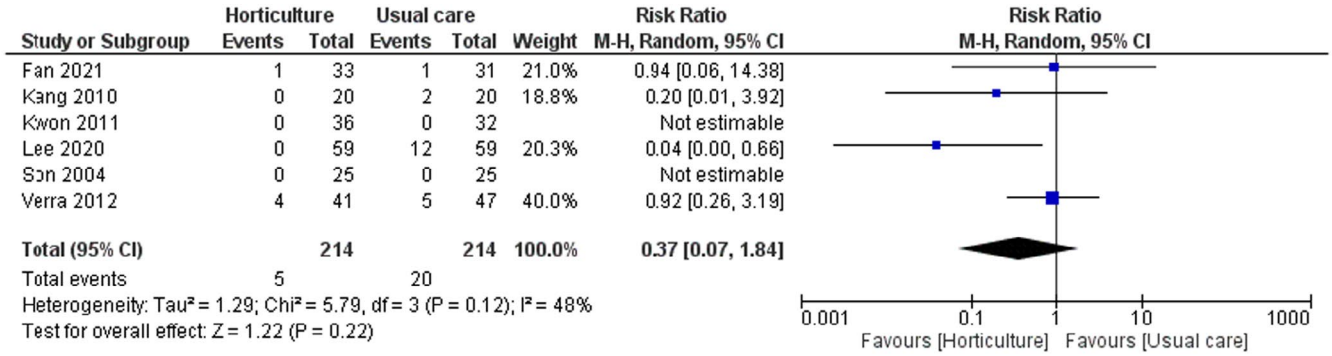

FIGURE 3 Comparison of the risk of dropping out between horticulture groups and usual care groups, using the mantel–haenszel random effects meta-analysis. Events refer to the number of participants who dropped out. Blues squares refer to risk ratios. Bigger squares indicate more events and a bigger diamond indicates greater uncertainty in the combined estimate.

Finally, Yun and Kim (2003) compared the effect of a horticultural intervention between severely and mildly depressed individuals. Because the difference in the baseline scores of these groups is substantial, we did not compare their post-intervention scores. The severely depressed group had a 5.5% reduction in their mean depression score and the mildly depressed group had a reduction of 16%. The number of participants who dropped out from these studies is unknown and no study reported whether adverse events occurred or not.

3.3 | Results from uncontrolled studies

From the 32 uncontrolled studies ($n = 517$ participants, from which only six were adolescents), 25 reported the baseline and post-intervention mean depression scores. Of these 25 studies, only Mizuno-Matsumoto et al. (2008) did not observe an improvement in participants' depressive symptoms (Figure 4). Most studies (64%) found a reduction greater than 20% in the mean depression score from baseline to post-intervention, and six studies (24%) found a reduction greater than 40%. Only one study focused on young people and documented a 4% improvement in the participants' mean depression score from baseline to post-intervention (Ascencio, 2020). Similar to the non-RCTs, the two unpublished uncontrolled studies reported improvements from pre- to post-intervention on participants' depressive symptoms (Ascencio, 2020; Park, Shoemaker, et al., 2015).

Only nine of the 32 uncontrolled studies reported the number of participants who dropped out. In seven of these studies, no dropout took place. In the other two studies, the percentage of participants who dropped out was approximately 25%. All but one study did not report whether adverse events took place or not; the only exception was Stowell et al. (2018), who reported that no adverse event occurred.

4 | DISCUSSION

In this study, we reviewed the results from 30 non-RCTs and 32 uncontrolled studies that assessed the effect of horticultural interventions on depressive symptoms. Findings from non-RCTs largely support the evidence provided by randomized studies of horticultural interventions (objective 1; Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023). In other words, on average, horticultural interventions plus usual care reduced adults' depressive symptoms more than usual care alone (Figure 2). Twenty-three of 24 non-RCTs with usable data for a meta-analysis suggested that the addition of horticultural activities to participants' normal daily routines tended to promote a reduction in their depressive symptoms, and most studies found a moderate or large effect (Figure 2a). Similar to the RCTs (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023), we observed some variability in the magnitude of the effect estimates across the included non-RCTs and uncontrolled studies, which might be due to the difference in participants, interventions, and the outcome measures used. As with non-RCTs, uncontrolled trials largely support the potential of horticultural interventions to improve depressive symptoms (Figure 4). These findings not only align with RCTs of horticultural interventions but also with recent systematic reviews indicating that some forest-based activities (Rosa et al., 2021) or nature-based adventure interventions (Rosa, Chaves, Collado, Larson, & Profice, 2023) may reduce adults' depressive symptoms more than usual care alone.

There is limited evidence regarding the impact of specific characteristics of participants or horticultural interventions on individuals' depressive symptoms (objective 2). This issue was not assessed by any RCT (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023) and was only assessed by two non-RCTs. Evidence from a non-RCT suggests that providing horticultural interventions once or twice a week will have a similar effect on people's depressive symptoms (Kim et al., 2020). The other study found a relatively larger improvement in depressive symptoms after a horticultural intervention for people with mild depression than for people with severe depression (Yun & Kim, 2003). Thus, horticultural interventions seem to be more beneficial for people with mild depression than for people with severe depression, and interventions with different lengths may produce similar effects on depression when the number of sessions and contact hours is identical. Nonetheless, this evidence should be seen as tentative since none of these studies

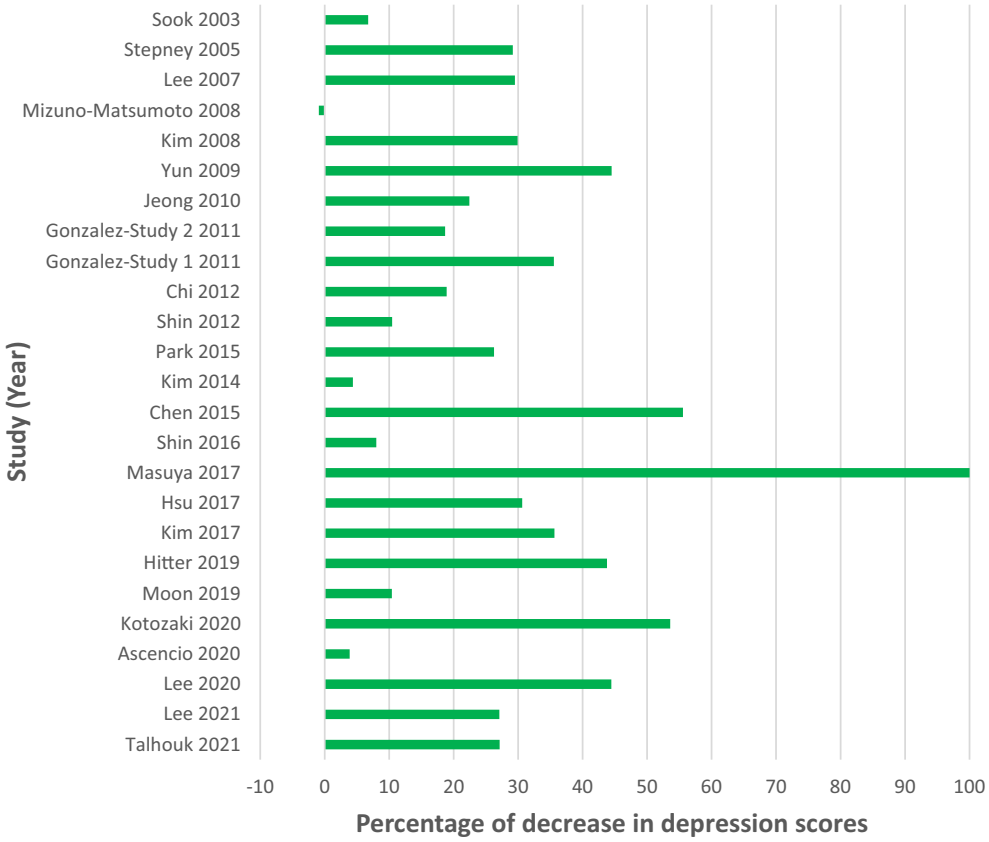

FIGURE 4 Percentage of change in mean depression scores from uncontrolled trials assessing depressive symptoms before and after horticultural interventions. Zero indicates no change, and positive change represents a decrease in depressive symptoms from baseline to post-intervention.

was randomized and the number of participants in each group was small (i.e., $n < 25$).

Like previous systematic reviews (Rosa et al., 2021; Rosa, Chaves, Collado, Larson, & Profice, 2023), our review failed to identify convincing evidence regarding the effect of nature-based interventions on children's and adolescents' depressive symptoms (objective 3). We found that only one study included six youth (i.e., adolescents) in the investigation (Ascencio, 2020). This study found a 4% reduction on participants' depressive symptoms from pre- to post-horticultural intervention, which was associated with many other interventions. Thus, to date, there is no convincing evidence regarding the impact of nature-based interventions on children or adolescents' depressive symptoms (Rosa et al., 2021; Rosa, Chaves, Collado, Larson, & Profice, 2023). One explanation for these findings might be the lack of stability in children's and adolescents' responses to depression outcome measures, an issue that deserves further attention from future studies (Stallwood et al., 2021).

We also checked potential publication bias (objective four), but there was no evidence of it. All four unpublished studies that provided usable data for a meta-analysis indicated that adding horticultural interventions to participants' normal routine promotes a greater reduction on depressive symptoms than usual care alone. The combined estimate from these unpublished studies was even larger than the combined estimate from all studies. Thus, horticultural interventions' potential to reduce depressive symptoms cannot be explained by the publication status of the studies.

Finally, we explore the possible adverse effects of horticultural interventions (objective five). According to our results, there was no evidence that participants drop out more from horticultural interventions than from usual care (Figure 3). Moreover, in most uncontrolled studies, no participant dropped out from the intervention. No adverse event was associated with the horticultural intervention in any study. Similar to forest-based interventions (Rosa et al., 2021), people seem to adhere well to horticultural interventions (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023), and adverse events during these interventions appeared to be rare.

4.1 | Study limitations

Our findings should be considered in light of several limitations. First, all studies included in our systematic review presented design limitations that might have biased their results. For example, in the non-RCTs, the allocation of participants to groups was not done through a random approach (Hernán & Robins, 2020; Higgins et al., 2019). Hence, systematic differences in prognostic variables (e.g., baseline depression score) might explain the differences in depressive symptoms at the end of the intervention

(Sterne et al., 2016). Moreover, 32 included studies did not have a comparison group (i.e., uncontrolled studies), preventing inferences regarding what should have occurred with the participants had they not received the horticultural intervention (Hernán & Robins, 2020). Furthermore, one limitation presented in all included studies was the inability to keep the participants unaware of the intervention they were receiving (i.e., blinding). In other words, participants knew when they were receiving the horticultural intervention. This lack of blinding might influence participants' decision to search for additional care if they are not satisfied with the group they were allocated to, or it might bias their reporting of depressive symptoms (Rosa & Delabrida, 2021; Sterne et al., 2016, 2019). Unfortunately, blinding is not feasible in studies of horticultural interventions; to reduce the risk of bias, studies might provide one alternative intervention to the comparison group such as physical exercise (e.g., Makizako et al., 2020). Finally, another common limitation of the included studies was the lack of a registered analysis plan matching the analyses performed in the paper, which would ensure that reporting of results was not selective (Sterne et al., 2016, 2019).

Whereas all included studies were affected by some kind of bias, it is unknown how much those biases explain the estimates of horticultural intervention effects that we observed. When considering studies with similar design limitations, researchers may have more confidence in the efficacy of interventions reported in studies with larger samples and larger estimates than in studies with fewer participants and smaller estimates. It is also important to note that design limitations do not always imply biased estimates (Moustgaard et al., 2020). Given that results found with RCTs and those found with non-RCTs and uncontrolled studies were quite similar, it appears that the design limitations of the reviewed studies in this systematic review did not bias the results substantially. However, additional research is essential to understand how study design may influence results. Furthermore, adherence to relevant Consolidated Standards of Reporting Trials (CONSORT) would improve the interpretation of the results for horticultural intervention studies (Moher et al., 2010).

Besides these limitations, a systematic review comprises many decisions that influence the interpretation of findings (Higgins et al., 2019). Here we describe how some of our decisions impact the findings' interpretation. First, we did not limit this review to specific participants (e.g., older adults), intervention characteristics (e.g., weekly sessions), and comparison groups like usual care. Hence, the included studies are different in important characteristics that somewhat preclude a comprehensive quantitative synthesis of all results (i.e., meta-analysis). We, therefore, chose to present a forest plot with effect estimates from the non-RCTs comparing horticultural interventions plus usual care with just usual care (Figure 2). Nevertheless, we recommend that readers not focus on the combined estimate from these studies. Instead, they may ponder how different kinds of horticultural interventions (including the kind of activities provided, their length, frequency, and duration) may improve the depressive symptoms of specific groups (e.g., older adults) as compared to the alternative interventions (i.e., usual care). More studies that isolate the impacts of specific variables are needed to better understand how unique characteristics of individuals and interventions might have influenced the study results.

Also linked to our criteria of eligibility, we included studies independent of whether or not their participants had a diagnosis of depression. We did this because every person can experience depressive symptoms (e.g., sad mood) to a certain degree. Many studies included people diagnosed with mental health problems related to but not necessarily involving just depression, such as adults with dementia (Kim et al., 2020; Yoon & Sung, 2017), Alzheimer (Han et al., 2009), and schizophrenia (Son et al., 2004). In fact, only a few studies focused on depressed participants (Gonzalez et al., 2011a; Hitter (Buru) et al., 2019; Korah et al., 2021; Song et al., 2010; Yun & Kim, 2003). Thus, more studies specifically focusing on depressed people are needed to better represent this population.

Concerning our methodology, we did not search for terms specific to elderly people, a population for whom horticultural therapy is particularly common, using phrases such as "dementia garden*" and "Alzheimer garden*". We also did not include the database CINAHL, frequently used by nurses and allied health professionals. This approach might have prevented us from identifying some eligible studies; we therefore recommend future systematic reviews consider including these terms and database. Finally, one researcher conducted the title and abstract screening and data extraction. This approach was efficient, but the risk of unintentionally excluding a potentially relevant study or making a mistake during data extraction might have been reduced if two researchers were involved in this process. Unfortunately, this was a necessary decision to facilitate the execution of this systematic review. Additionally, most systematic reviews are expected to fail to include some studies relevant to the research question since search strategies are (generally) not perfectly effective (Higgins et al., 2019).

5 | CONCLUSION AND NEXT STEPS

To our knowledge, our systematic review is the most comprehensive summary to date of non-RCTs and uncontrolled studies estimating the effect of horticultural interventions on depressive symptoms. We found results that were relatively consistent with those reported in RCTs (Rosa, Chaves, Collado, Larson, Lee, & Profice, 2023), indicating that horticultural interventions plus usual care may reduce adults' depressive symptoms more than usual care alone. In line with previous studies (e.g., Bratman et al., 2019; Hartig, 2021; Rosa, Chaves, Collado, & Harper, 2023), our findings support the health benefits of some nature-based interventions and, as such, they may be considered by health professionals as a potential strategy for preventing or treating depression in adults. Evidence related to children and adolescents is still insufficient, however. We were unable to confidently determine which specific characteristics of the participants, interventions, or outcome measures are associated with a stronger impact of horticultural interventions on depressive symptoms. Nonetheless, there is tentative evidence indicating

that a horticultural intervention may be more effective in improving mild depression compared to severe depression. There is also tentative evidence that the length of the intervention may not play a role in the effectiveness of a horticultural intervention provided the activities involved and the number of sessions are similar. While these findings shed some light on the critical question of optimal nature dosage (Shanahan et al., 2016), more research on the efficacy of variable horticultural interventions across different populations is needed. For example, a study could provide a comparable intervention to two different groups of individuals or a slightly different intervention to the same participants.

Our findings also suggest that people may adhere well to horticultural interventions (i.e., low dropout rates) and that adverse events during and after these interventions are likely rare. However, exploring these issues within a wider range of study contexts is critical. For instance, more work is needed in places where the effect of horticultural interventions has been seldom examined, such as Latin America, Africa, and Oceania. It may also be prudent to focus on people diagnosed with depression as well as young people.

Future systematic reviews could also examine other effects of horticultural interventions, including the possible effects of these activities on different mental (e.g., loneliness, anxiety, and anger) and physical (e.g., weight loss) outcomes. Systematic reviews that directly assess the effect of horticultural interventions on specific symptoms of depression (e.g., anhedonia and mood) are also warranted since our review focused on aggregate scores from depression outcome measures, not on specific symptoms. The analysis of specific symptoms could inform understanding of how horticultural interventions affect specific symptoms of depression like sleep problems, sad mood, and anhedonia (Fried & Nesse, 2015). Lastly, studies should consider the cost-effectiveness of implementing horticultural interventions compared to more conventional strategies that are typically employed to prevent or treat depression and other mental health disorders. As research progresses, the integration of results from both RCTs, non-RCTs, and uncontrolled studies will be critical to characterizing the potential benefits and risks of horticultural therapy as a health promotion strategy.

AUTHOR CONTRIBUTIONS

Our study was a global review and was based on a meta-analysis of secondary data rather than primary data. As such, there was no local data collection. However, the geographical distribution of the authorship team broadly represents the major regions of interest in the meta-analysis, supporting the inclusion of data from peer-reviewed studies published in local languages and ensuring the appropriate interpretation of data and results from each region. Claudio D. Rosa designed the methodology, conducted the systematic review, analysed the data, and wrote the first version of the manuscript. Talisson S. Chaves contributed to the methodology, checked the studies included and excluded at the full-text selection phase, and edited the manuscript. Silvia Collado and Lincoln R. Larson contributed to the methodology, provided supervision throughout the study, and edited the manuscript. KangJae Jerry Lee identified and translated some of the included studies, and edited the manuscript. Christiana C. Profice contributed to the supervision of the work and edited the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflict of interest.

DATA AVAILABILITY STATEMENT

All data analysed in this manuscript are reported in the text or shared as Supporting Information.

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REFERENCES

American Horticultural Therapy Association. (2017). *AHTA definitions and positions paper*. American Horticultural Therapy Association.

American Psychiatric Association (Ed.). (2014). *Manual diagnóstico e estatístico de transtornos mentais: DSM-5 [Diagnostic and statistical manual of mental disorders: DSM-5]* (5th ed.). Artmed.

Ascencio, J. M. (2020). *Giving language to horticultural therapy: Framing horticultural therapy through the lens of empirically supported therapies*. Colorado State University.

Berk, M., & Jacka, F. N. (2019). Diet and depression—From confirmation to implementation. *JAMA*, *321*(9), 842–843. https://doi.org/10.1001/jama.2019.0273

Bernaras, E., Jaureguizar, J., & Garaigordobil, M. (2019). Child and adolescent depression: A review of theories, evaluation instruments, prevention programs, and treatments. *Frontiers in Psychology*, *10*, 543. https://doi.org/10.3389/fpsyg.2019.00543

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J. J., Hartig, T., Kahn, P. H., Kuo, M., Lawler, J. J., Levin, P. S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., … Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, *5*(7), eaax0903. https://doi.org/10.1126/sciadv.aax0903

Catalan-Matamoros, D., Gomez-Conesa, A., Stubbs, B., & Vancampfort, D. (2016). Exercise improves depressive symptoms in older adults: An umbrella review of systematic reviews and meta-analyses. *Psychiatry Research*, *244*, 202–209. https://doi.org/10.1016/j.psychres.2016.07.028

Cipriani, A., Furukawa, T. A., Salanti, G., Chaimani, A., Atkinson, L. Z., Ogawa, Y., Leucht, S., Ruhe, H. G., Turner, E. H., Higgins, J. P. T., Egger, M., Takeshima, N., Hayasaka, Y., Imai, H., Shinohara, K., Tajika, A., Ioannidis, J. P. A., & Geddes, J. R. (2018). Comparative efficacy and acceptability of 21 antidepressant drugs for the acute treatment of adults with major depressive disorder: A systematic review and network meta-analysis. *The Lancet*, *391*(10128), 1357–1366. https://doi.org/10.1016/S0140-6736(17)32802-7

Clatworthy, J., Hinds, J., & Camic, P. M. (2013). Gardening as a mental health intervention: A review. *Mental Health Review Journal*, *18*(4), 214–225. https://doi.org/10.1108/MHRJ-02-2013-0007

Cuijpers, P., Noma, H., Karyotaki, E., Vinkers, C. H., Cipriani, A., & Furukawa, T. A. (2020). A network meta-analysis of the effects of psychotherapies, pharmacotherapies and their combination in

the treatment of adult depression. *World Psychiatry*, *19*(1), 92–107. https://doi.org/10.1002/wps.20701

Fan, C.-C., Choy, C.-S., Huang, C.-M., Chih, P.-S., Lee, C.-C., Lin, F.-H., & Guo, J. (2021). *The effects of a combination of 3d virtual reality and hands-on horticultural activities on community-dwelling older adults' mental health: A quasi-experimental study*. Research Square.

Fernee, C. R., Gabrielsen, L. E., Andersen, A. J. W., & Mesel, T. (2017). Unpacking the black box of wilderness therapy. *Qualitative Health Research*, *27*(1), 114–129. https://doi.org/10.1177/1049732316655776

Fried, E. I., Flake, J. K., & Robinaugh, D. J. (2022). Revisiting the theoretical and methodological foundations of depression measurement. *Nature Reviews Psychology*, *1*(6), 358–368. https://doi.org/10.1038/s44159-022-00050-2

Fried, E. I., & Nesse, R. M. (2015). Depression sum-scores don't add up: Why analyzing specific depression symptoms is essential. *BMC Medicine*, *13*(1), 72. https://doi.org/10.1186/s12916-015-0325-4

Furukawa, T. A., Cipriani, A., Barbui, C., Brambilla, P., & Watanabe, N. (2005). Imputing response rates from means and standard deviations in meta-analyses. *International Clinical Psychopharmacology*, *20*(1), 49–52. https://doi.org/10.1097/00004850-200501000-00010

Gonzalez, M. T., Hartig, T., Patil, G. G., Martinsen, E. W., & Kirkevold, M. (2009). Therapeutic horticulture in clinical depression: A prospective study. *Research and Theory for Nursing Practice*, *23*(4), 312–328. https://doi.org/10.1891/1541-6577.23.4.312

Gonzalez, M. T., Hartig, T., Patil, G. G., Martinsen, E. W., & Kirkevold, M. (2010). Therapeutic horticulture in clinical depression: A prospective study of active components. *Journal of Advanced Nursing*, *66*(9), 2002–2013. https://doi.org/10.1111/j.1365-2648.2010.05383.x

Gonzalez, M. T., Hartig, T., Patil, G. G., Martinsen, E. W., & Kirkevold, M. (2011a). A prospective study of existential issues in therapeutic horticulture for clinical depression. *Issues in Mental Health Nursing*, *32*(1), 73–81. https://doi.org/10.3109/01612840.2010.528168

Gonzalez, M. T., Hartig, T., Patil, G. G., Martinsen, E. W., & Kirkevold, M. (2011b). A prospective study of group cohesiveness in therapeutic horticulture for clinical depression. *International Journal of Mental Health Nursing*, *20*(2), 119–129. https://doi.org/10.1111/j.1447-0349.2010.00689.x

Han, K., Lee, S., & Suh, J. (2009). Effect of group horticultural therapy on the change of depression and self-esteem in older adult. *Journal of Korea Society for Plants People and Environment*, *12*(4), 1–12.

Hartig, T. (2021). Restoration in nature: Beyond the conventional narrative. In A. R. Schutte, J. Torquati, & J. R. Stevens (Eds.), *Nature and psychology: Biological, cognitive, developmental, and social pathways to well-being* (pp. 89–151). Springer.

Hernán, M. A., & Robins, J. M. (2020). *Causal inference: What if*. CRC Press.

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2019). *Cochrane handbook for systematic reviews of interventions* (2nd ed.). John Wiley & Sons.

Hitter (Buru), T., Kállay, É., Olar, L. E., Ştefan, R., Buta, E., Chiorean, S., Cantor, M., & Papuc, I. (2019). The effect of therapeutic horticulture on depression and kynurenine pathways. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *47*(3), 804–812. https://doi.org/10.15835/nbha47311544

Houge Mackenzie, S., Hodge, K., & Filep, S. (2021). How does adventure sport tourism enhance well-being? A conceptual model. *Tourism Recreation Research*, *48*, 3–16. https://doi.org/10.1080/02508281.2021.1894043

Hwang, H.-J., Lee, Y.-A., Song, J.-E., & Son, K.-C. (2007). Effect of horticultural therapy based upon reality therapy on the reduction of depression, the change in parental sense of competence, and stress coping types of elementary student's mother. *Korean Journal of Horticultural Science & Technology*, *25*(3), 268–276.

Jeung, E.-K., Lee, M.-H., & Suh, J.-K. (2001). Effects of horticultural therapy on the depression of psychiatric patients. *Journal of the Korean Flower Research Society*, *9*(1), 17–21.

Kam, M. C. Y., & Siu, A. M. H. (2010). Evaluation of a horticultural activity programme for persons with psychiatric illness. *Hong Kong Journal of Occupational Therapy*, *20*(2), 80–86. https://doi.org/10.1016/S1569-1861(11)70007-9

Kang, H.-Y., Bae, Y.-S., Kim, E.-H., Lee, K.-S., Chae, M.-J., & Ju, R.-A. (2010). An integrated dementia intervention for Korean older adults. *Journal of Psychosocial Nursing and Mental Health Services*, *48*(12), 42–50. https://doi.org/10.3928/02793695-20100930-01

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Kellert, S. R., & Wilson, E. O. (1993). *The Biophilia hypothesis*. Island Press.

Kelley, R. J., Waliczek, T. M., & Le Duc, F. A. (2017). The effects of greenhouse activities on psychological stress, depression, and anxiety among university students who served in the U.S. armed forces. *HortScience*, *52*(12), 1834–1839. https://doi.org/10.21273/HORTSCI12372-17

Kim, H.-J., Yang, Y., Oh, J.-G., Oh, S., Choi, H., Kim, K. H., & Kim, S. H. (2016). Effectiveness of a community-based multidomain cognitive intervention program in patients with Alzheimer's disease. *Geriatrics and Gerontology International*, *16*(2), 191–199. https://doi.org/10.1111/ggi.12453

Kim, K. H., Lee, H. R., Song, M. O., Chung, S. H., & Chung, H. J. (2006). Effects of horticultural therapy program on serum cortisol, pain, anxiety and depression of the hospice patients. *Korean Journal of Horticultural Science & Technology*, *24*(1), 95–103.

Kim, M. Y., Kim, G. S., Matson, N. S., & Kim, W. S. (2010). Effects of horticultural occupational therapy on the physical and psychological rehabilitation of patients with hemiplegia after stroke. *Korean Journal of Horticultural Science and Technology*, *28*(5), 884–890.

Kim, W., Lim, S.-K., Chung, E.-J., & Woo, J.-M. (2009). The effect of cognitive behavior therapy-based psychotherapy applied in a forest environment on physiological changes and remission of major depressive disorder. *Psychiatry Investigation*, *6*(4), 245–254. https://doi.org/10.4306/pi.2009.6.4.245

Kim, Y. H., Jo, H. S., Park, C.-S., Kang, K., Lee, E. S., Jo, S. H., Bae, H.-O., & Huh, M. R. (2020). Comparing the effectiveness of the frequency and duration of the horticultural therapy program on elderly women with mild cognitive impairment and mild dementia. *Journal of People, Plants, and Environment*, *23*(1), 35–46. https://doi.org/10.11628/ksppe.2020.23.1.35

Korah, T., Morrison, D., Mason, D., Diehl, E. R., & Bussing, R. (2021). Therapeutic horticulture as a therapeutic intervention in patients receiving electroconvulsive therapy (ECT) treatment for major depressive disorder. *Cureus*, *13*, e17363. https://doi.org/10.7759/cureus.17363

Kwon, Y.-H., Song, M.-O., & Kim, C.-N. (2011). Effects of horticulture therapy on depression and stress in patient of hospice unit. *Journal of the Korea Academia-Industrial Cooperation Society*, *12*(10), 4394–4402. https://doi.org/10.5762/KAIS.2011.12.10.4394

Lee, A.-Y., Park, S.-A., Son, K.-C., & Park, H.-G. (2018). Determining the effects of a horticultural therapy program for improving the upper limb function and balance ability of stroke patients. *HortScience*, *53*(1), 110–119. https://doi.org/10.21273/HORTSCI12639-17

Lee, S., Kim, M. S., & Suh, J. K. (2008). Effects of horticultural therapy of self-esteem and depression of battered women at a shelter in Korea. *VIII International People-Plant Symposium*, 139–142. https://doi.org/10.17660/ActaHortic.2008.790.19

Lee, S., Moon, J. H., Jeong, S. J., Gim, G. M., & Jea, E. S. (2014). Effects of horticultural therapy program focusing on cultivation activities on mental health of female adult prisoners. *Journal of Korea Society for*

Plants People and Environment, *17*(4), 267–273. https://doi.org/10.11628/ksppe.2014.17.4.267

Lee, S., Moon, J. H., Jeong, S. J., & Lee, Y. (2013). Effects of horticultural therapy program focusing on cultivating activities for prisoners scheduled to be released on depression and salivary cortisol. *Journal of Korea Society for Plants People and Environment*, *16*(4), 173–180. https://doi.org/10.11628/ksppe.2013.16.4.173

Lee, S.-j., Lee, S., & Suh, J. (2010). Effects of horticultural therapy program on the acculturation stress and depression of the internationally married migrant women. *Journal of the Korean Society People Plants Environment*, *13*(4), 15–22.

Lin, T.-Y., Huang, C.-M., Hsu, H.-P., Liao, J.-Y., Cheng, V. Y.-W., Wang, S.-W., & Guo, J.-L. (2020). Effects of a combination of three-dimensional virtual reality and hands-on horticultural therapy on institutionalized older adults' physical and mental health: Quasi-experimental design. *Journal of Medical Internet Research*, *22*(11), e19002. https://doi.org/10.2196/19002

Lopresti, A. L. (2019). It is time to investigate integrative approaches to enhance treatment outcomes for depression? *Medical Hypotheses*, *126*, 82–94. https://doi.org/10.1016/j.mehy.2019.03.008

Makizako, H., Tsutsumimoto, K., Doi, T., Makino, K., Nakakubo, S., Liu-Ambrose, T., & Shimada, H. (2020). Exercise and horticultural programs for older adults with depressive symptoms and memory problems: A randomized controlled trial. *Journal of Clinical Medicine*, *9*(1), 99. https://doi.org/10.3390/jcm9010099

Masuya, J., Ota, K., & Mashida, Y. (2014). The effect of a horticultural activities program on the psychologic, physical, cognitive function and quality of life of elderly people living in nursing homes. *International Journal of Nursing Clinical Practices*, *1*(109), 1–4. https://doi.org/10.15344/2394-4978/2014/109

McCormack, J., & Korownyk, C. (2018). Effectiveness of antidepressants. *BMJ*, *360*, k1073. https://doi.org/10.1136/bmj.k1073

Mizuno-Matsumoto, Y., Kobashi, S., Hata, Y., Ishikawa, O., & Asano, F. (2008). Horticultural therapy has beneficial effects on brain functions in cerebrovascular diseases. *IC-MED International Journal of Intelligent Computing in Medical Sciences and Image Processing*, *2*(3), 169–182. https://doi.org/10.1080/1931308X.2008.10644162

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M., & Altman, D. G. (2010). CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. *International Journal of Surgery*, *10*(1), 28–55. https://doi.org/10.1136/bmj.c869

Moustgaard, H., Clayton, G. L., Jones, H. E., Boutron, I., Jørgensen, L., Laursen, D. R. T., Olsen, M. F., Paludan-Müller, A., Ravaud, P., Savović, J., Sterne, J. A. C., Higgins, J. P. T., & Hróbjartsson, A. (2020). Impact of blinding on estimated treatment effects in randomised clinical trials: Meta-epidemiological study. *BMJ*, *368*, l6802. https://doi.org/10.1136/bmj.l6802

Murroni, V., Cavalli, R., Basso, A., Borella, E., Meneghetti, C., Melendugno, A., & Pazzaglia, F. (2021). Effectiveness of therapeutic gardens for people with dementia: A systematic review. *International Journal of Environmental Research and Public Health*, *18*(18), 9595. https://doi.org/10.3390/ijerph18189595

Nicholas, S. O., Giang, A. T., & Yap, P. L. K. (2019). The effectiveness of horticultural therapy on older adults: A systematic review. *Journal of the American Medical Directors Association*, *20*(10), 1351.e1–1351.e11. https://doi.org/10.1016/j.jamda.2019.06.021

Park, S.-A., Lee, A.-Y., Son, K.-C., Lee, W.-L., & Kim, D.-S. (2016). Gardening intervention for physical and psychological health benefits in elderly women at community centers. *HortTechnology*, *26*(4), 474–483. https://doi.org/10.21273/horttech.26.4.474

Park, S.-A., Shoemaker, C. A., Harms, S., O'Nell, D., & Oh, D.-M. (2015). An eight-week horticultural therapy program for stroke outpatients: A case study. *XI International People Plant Symposium on Diversity: Towards a New Vision of Nature*, 71–72. https://doi.org/10.17660/ActaHortic.2015.1093.6

Park, S. H., & Jung, T. Y. (2017). The effects of horticultural activity based upon REBT group counseling on the self-expression and the degree of depression of the female marriage immigrants. *Journal of Korea Society for Plants People and Environment*, *20*(2), 165–174. https://doi.org/10.11628/ksppe.2017.20.2.165

Park, S.-A., Lee, J.-Y., Lee, A.-Y., Park, S.-W., & Son, K.-C. (2015). Horticultural therapy program based on the stress immunization training for reducing depression symptom in the patients with stroke. *Journal of Korea Society for Plants People and Environment*, *18*(3), 159–167. https://doi.org/10.11628/ksppe.2015.18.3.159

Penman, C. J. (2015). *Gardening modifies the patterns of brain activation and enhances the mental health profile of healthy women*. University of Florida.

Review Manager (RevMan) [Computer program] (5.4.1). (2020). The Cochrane Collaboration.

Riedel, M., Möller, H.-J., Obermeier, M., Schennach-Wolff, R., Bauer, M., Adli, M., Kronmüller, K., Nickel, T., Brieger, P., Laux, G., Bender, W., Heuser, I., Zeiler, J., Gaebel, W., & Seemüller, F. (2010). Response and remission criteria in major depression—A validation of current practice. *Journal of Psychiatric Research*, *44*(15), 1063–1068. https://doi.org/10.1016/j.jpsychires.2010.03.006

Rosa, C. D. (2024). *The effect of nature-based intervention on depression*. Universidade Estadual de Santa Cruz. https://doi.org/10.13140/RG.2.2.30157.24806

Rosa, C. D., Chaves, T. S., Collado, S., & Harper, N. J. (2023). Improving the analysis and reporting of studies of nature-based adventure interventions: A review of studies published in JAEOL. *Journal of Adventure Education and Outdoor Learning*, *24*, 642–661. https://doi.org/10.1080/14729679.2023.2196638

Rosa, C. D., Chaves, T. S., Collado, S., Larson, L. R., Lee, K. J., & Profice, C. C. (2023). Horticultural interventions may reduce adults' depressive symptoms: A systematic review of randomized controlled trials. *Journal of Environmental Psychology*, *91*, 102112. https://doi.org/10.1016/j.jenvp.2023.102112

Rosa, C. D., Chaves, T. S., Collado, S., Larson, L. R., & Profice, C. C. (2023). The effect of nature-based adventure interventions on depression: A systematic review. *Environment and Behavior*, *55*, 140–174. https://doi.org/10.1177/00139165231174615

Rosa, C. D., & Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: Setting the ground for future research. *Frontiers in Psychology*, *10*, 763. https://doi.org/10.3389/fpsyg.2019.00763

Rosa, C. D., & Collado, S. (2020). Enhancing nature conservation and health: Changing the focus to active pro-environmental behaviours. *Psychological Studies*, *65*(1), 9–15. https://doi.org/10.1007/s12646-019-00516-z

Rosa, C. D., & Delabrida, Z. (2021). Método experimental e ensaios clínicos: Metassíntese de artigos de revisão publicados em português [Experimental method and clinical trials: Metassynthesis of review articles published in Portuguese]. *Psico*, *52*(4), e36259. https://doi.org/10.15448/1980-8623.2021.4.36259

Rosa, C. D., Larson, L. R., Collado, S., Geiger, S. J., Profice, C. C., & Menuchi, M. R. T. P. (2024). Associations between well-being and nature-based recreation: A cross-sectional study among adults in the United States, Brazil, and Spain. *Journal of Environmental Psychology*, *99*, 102438. https://doi.org/10.1016/j.jenvp.2024.102438

Rosa, C. D., Larson, L. R., Collado, S., & Profice, C. C. (2021). Forest therapy can prevent and treat depression: Evidence from meta-analyses. *Urban Forestry & Urban Greening*, *57*, 126943. https://doi.org/10.1016/j.ufug.2020.126943

Selph, S. S., & McDonagh, M. S. (2019). Depression in children and adolescents: Evaluation and treatment. *American Family Physician*, *100*(10), 609–617.

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for

systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ*, *349*, g7647. https://doi.org/10.1136/bmj.g7647

Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Dean, J., Barber, E., & Fuller, R. A. (2016). Health benefits from nature experiences depend on dose. *Scientific Reports*, *6*, 28551. https://doi.org/10.1038/srep28551

Shao, Y., Elsadek, M., & Liu, B. (2020). Horticultural activity: Its contribution to stress recovery and wellbeing for children. *International Journal of Environmental Research and Public Health*, *17*(4), 1229. https://doi.org/10.3390/ijerph17041229

Shin, S. B., Kim, T. U., Lee, J. H., Kim, J. Y., & Lee, S. (2016). Horticultural therapy in patients with stroke: Three case series. *Journal of Korean Society for People Plants and Environment*, *19*(1), 49–53. https://doi.org/10.11628/ksppe.2016.19.1.049

Shin, W. S., Shin, C. S., & Yeoun, P. S. (2012). The influence of forest therapy camp on depression in alcoholics. *Environmental Health and Preventive Medicine*, *17*(1), 73–76. https://doi.org/10.1007/s12199-011-0215-0

Singh, B., Olds, T., Curtis, R., Dumuid, D., Virgara, R., Watson, A., Szeto, K., O'Connor, E., Ferguson, T., Eglitis, E., Miatke, A., Simpson, C. E., & Maher, C. (2023). Effectiveness of physical activity interventions for improving depression, anxiety and distress: An overview of systematic reviews. *British Journal of Sports Medicine*, *57*(18), 1203–1209. https://doi.org/10.1136/bjsports-2022-106195

Soga, M., Gaston, K. J., & Yamaura, Y. (2017). Gardening is beneficial for health: A meta-analysis. *Preventive Medicine Reports*, *5*, 92–99. https://doi.org/10.1016/j.pmedr.2016.11.007

Son, K. C., Um, S. J., Kim, S. Y., Song, J. E., & Kwack, H. R. (2004). Effect of horticultural therapy on the changes of self-esteem and sociality of individuals with chronic schizophrenia. *XXVI IHC—Horticulture, Human Well-Being and Life Quality*, 185–191. https://doi.org/10.17660/ActaHortic.2004.639.23

Song, M. J., Kim, M. Y., Sim, I. S., & Kim, W. S. (2010). Evaluation of horticultural therapy on the emotional improvement of depressed patients by using heart rate variability. *Korean Journal of Horticultural Science and Technology*, *28*(6), 1066–1071.

Šorytė, D., Rosa, C. D., Collado, S., & Pakalniškienė, V. (2023). The effects of nature-based interventions on individuals' environmental behaviors: Protocol for a systematic review of controlled trials. *Frontiers in Psychology*, *14*, 1145720. https://doi.org/10.3389/fpsyg.2023.1145720

Stallwood, E., Monsour, A., Rodrigues, C., Monga, S., Terwee, C., Offringa, M., & Butcher, N. J. (2021). Systematic review: The measurement properties of the children's depression rating scale–revised in adolescents with major depressive disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *60*(1), 119–133. https://doi.org/10.1016/j.jaac.2020.10.009

Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A.-W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., … Higgins, J. P. (2016). ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*, *355*, i4919. https://doi.org/10.1136/bmj.i4919

Sterne, J. A., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H.-Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., … Higgins, J. P. T. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ*, *366*, l4898. https://doi.org/10.1136/bmj.l4898

Stowell, D. R., Owens, G. P., & Burnett, A. (2018). A pilot horticultural therapy program serving veterans with mental health issues: Feasibility and outcomes. *Complementary Therapies in Clinical Practice*, *32*, 74–78. https://doi.org/10.1016/j.ctcp.2018.05.007

Sturm, J., Plöderl, M., Fartacek, C., Kralovec, K., Neunhäuserer, D., Niederseer, D., Hitzl, W., Niebauer, J., Schiepek, G., & Fartacek, R. (2012). Physical exercise through mountain hiking in high-risk suicide patients. A randomized crossover trial. *Acta Psychiatrica Scandinavica*, *126*(6), 467–475. https://doi.org/10.1111/j.1600-0447.2012.01860.x

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*(3), 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7

Verra, M. L., Angst, F., Beck, T., Lehmann, S., Brioschi, R., Schneiter, R., & Aeschlimann, A. (2012). Horticultural therapy for patients with chronic musculoskeletal pain: Results of a pilot study. *Alternative Therapies in Health and Medicine*, *18*(2), 44–50. http://www.ncbi.nlm.nih.gov/pubmed/22516884

Vickers, A. J. (2001). The use of percentage change from baseline as an outcome in a controlled trial is statistically inefficient: A simulation study. *BMC Medical Research Methodology*, *1*(1), 6. https://doi.org/10.1186/1471-2288-1-6

Wilson, E. O. (1984). *Biophilia*. MIT Press.

World Health Organization (WHO). (2022). Mental Health and COVID-19: Early evidence of the pandemic's impact. https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci_Brief-Mental_health-2022.1

Yavne, Y., Kabaha, A., Rosen, T., Avisar, I., Orbach, H., Amital, D., & Amital, H. (2019). The powers of flowers: Evaluating the impact of floral therapy on pain and psychiatric symptoms in fibromyalgia. *The Israel Medical Association Journal*, *21*(7), 449–453.

Yoo, Y.-K., & Jeong, H.-Y. (2010). Effect of horticultural therapy program on the depression and self-esteem of the older adult in facilities. *Journal of the Korean Society People Plants Environment*, *13*(4), 7–15.

Yoon, M. J., & Sung, K. M. (2017). The effects of a horticultural program based on Cox's interaction model on ability for daily life and depression in older patients with mild dementia. *The Korean Journal of Rehabilitation Nursing*, *20*(1), 12–21. https://doi.org/10.7587/kjrehn.2017.12

Yun, S.-Y., & Kim, H.-Y. (2003). Effect of horticultural therapy on the decrease of depression of the old adults. *Journal of Korea Society for Plants People and Environment*, *6*(3), 19–25.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Data S1: The effect of horticultural interventions on depression: A systematic review protocol.

Data S2: Meta-data: NRCTs and uncontrolled studies.

Data S3: Characteristics of uncontrolled studies.

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