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Effectiveness of green health prescribing and nature-based interventions in primary care and community setting for older adults – A systematic review

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Abstract

Background

Green Health Prescribing involves health and care professionals recommending structured, nature-based activities, such as gardening, walking in green spaces, or cultural activities outdoors. With population ageing and increasing pressure on healthcare systems, Green Health Prescribing has been proposed as a potentially cost-effective approach to support healthy ageing in older adults with long-term conditions. This review summarises evidence on the effectiveness of Green Health Prescribing and related nature-based interventions for older adults globally.

Methods

A systematic review was conducted of intervention studies reporting quantitative outcomes of nature-based interventions for adults aged 50 years and over in primary or community care settings. Eligible designs included randomised trials, comparative studies, and before–after studies. Searches up to October 2024 were performed in major medical, psychological, social science, and environmental databases, alongside grey literature sources. Study selection, data extraction, and quality appraisal were undertaken independently by at least two reviewers. Quantitative findings were synthesised narratively using a Grading of Recommendations, Assessment, Development and Evaluation–informed approach, with reporting guided by established systematic review standards. PPIE and poviders input informed the design and interpretation of findings.

Results

Twenty-one studies, including 11 randomised trials, evaluated a range of interventions among older adults living in the community or in residential care. Interventions included nature-based therapies, exercise in green spaces, indoor gardening, and horticultural therapy. Many studies reported improvements in at least one outcome; however, statistically significant effects compared with control conditions were uncommon. Evidence suggested potential benefits for quality of life, mental health, physical function, fatigue, loneliness, and social connectedness, but findings were inconsistent. Overall certainty of evidence was low or very low, largely due to small sample sizes, risk of bias, and limited replication across outcomes.

Conclusions

Evidence supporting the effectiveness of Green Health Prescribing and nature-based interventions for older adults remains limited. Because of the continued policy priority and funding for green space prescribing, there is a clear need for high-quality, pragmatic trials and implementation studies, particularly among older adults with limited access to green spaces, to better assess health outcomes and cost-effectiveness in primary and community care.

Systematic review registration

CRD42025603199

1. Background

Existing literature has indicated a strong association between exposure to nature and improved mental, physical and social wellbeing [1]. This relationship holds particular significance for older adults, a demographic that is disproportionately affected by social isolation and often experiences reduced access to outdoor green spaces [2]. Healthcare sectors globally are recognising the potential benefits of being surrounded by natural environments or connected with nature in some other ways. Green Health Prescribing (GHP) refers to prescription by healthcare professionals of nature-based activities, that utilise materials sourced from or in connection with nature, and/or undertaking activities in the natural environment to benefit human health [3]. GHP is a form of social prescribing, a broader practice connecting patients to community based and non-clinical organisations providing support which may include, but is not limited to, nature-based activities [4]. In 2024 one million pounds in green social prescribing grants was awarded to NHS charities [5].

GHP directly involves nature-based interventions (NBIs) such as community gardening, horticulture projects, and other physical or culture-based activities conducted in greenspace or other natural environments [6].

This review will focus on the effectiveness of GHP for older people in primary and community care settings. With the number of people aged 60 years and older projected to increase from 1.1 to 1.4 billion by 2030 [7], addressing physical, psychological and social determinants of health in older people using preventative approaches have become critical. Aging is associated with reducing levels of physical activity and increasing sedentary lifestyles leading to detrimental health outcomes [8], [9]. GHP may offer an effective approach to maintaining or improving healthy lifestyle behaviours, with associated benefits for physical and mental health. Previous research has demonstrated that frequent engagement with green or blue space (water environments, including oceans, lakes, rivers, ponds) may reduce the risk of diabetes, cardiovascular disease, cancer, anxiety and depressive symptoms [10] [11], [12]. Alongside these health benefits, NBIs may yield social benefits for participants, increasing social connectedness and reducing loneliness which can exacerbate health issues in older adults [13]. Nature-based activities can be modified to take place indoors to overcome mobility problems and safety concerns for older adults [14] [15], [16].

Evidence shows that GHP is gaining acceptance among general practitioners (GPs) leading to a growing implementation of prescribed NBIs across the UK [17], [18]. In a survey in a survey of Scottish GPs 80% were aware and willing to refer to GSP but have concerns about accessibility for patients from deprived area [19]. There is, therefore, a need to understand how GHP can be leveraged to prevent and treat ill-health in these communities. This emphasises the importance of developing GHP services which are effective, accessible and flexible for transferability to different geographical locations [20]. Currently, there is a gap in sufficient quantitative evidence to support the implementation of GHP within healthcare system globally, which this review aims to fill.

1.1 Aims and research questions

This systematic review aimed to synthesise the literature on the effectiveness of GHP and participation in NBIs in primary and community care settings on the health and wellbeing of older adults with a specific focus on economically deprived communities.

For this systematic review of quantitative evidence, we aimed to answer the following research question: What are the health and wellbeing benefits of GHP and participation in NBIs, compared to standard care or other interventions for older people in primary or community care settings, with an emphasis on those living in areas of high socioeconomic deprivation?

2. Methods

2.1 Aims and research questions

We followed guidance from the Cochrane Handbook for Systematic Reviews of Interventions in undertaking the review [21]; the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [22] [23], the Synthesis Without Meta-analysis (SWiM) guidance [24] for data extracted from comparative designs (RCTs or pseudo-experimental studies) an approach informed by GRADE reporting results and Grading of Recommendations Assessments, Development an Evaluation approach (GRADE) [25] was used. Reporting checklists for PRISMA, SWiM and GRADE are available in Supplementary files, Appendices 1,2 and 3. The review has been registered on PROSPERO (registration no. CRD42025603199).

While the focus of this review was on GHP, i.e. prescribed NBIs, our initial scoping of the literature indicated that the number of relevant studies was likely to be very small. Consequently, quantitative studies of NBIs which were not explicitly prescribed by a healthcare professional, but where participants were recruited from any of the relevant settings (e.g. studies inviting participants directly through community organisations) were also included if they were specifically targeted at older adults and if they adopted an RCT design. Full study selection criteria are provided in Table 1. We applied no limits on country of study conduct, but only included completed studies and not abstracts or studies that did not report sufficient details for data extraction and quality appraisal.

Table 1
Study selection criteria

Domain	Criteria
Design	Inclusion: randomised controlled trials (RCTs), non-randomised studies of interventions with or without a control group. Exclusion: observational studies exploring associations between exposure to green space / natural environment (which was spontaneous and not prescribed or recommended by a health professional) and outcomes.
Setting	Primary care and community settings including general practice, out-patient care, integrated care services, residential care. Studies conducted in multiple settings were excluded unless data from the setting listed above were reported separately.
Population	Adults aged 50 years or above or studies reporting a mean age of 50 years and above.
Intervention	GHP was broadly defined as NBIs (this could involve undertaking activities in green space, urban natural environment, forest, garden, park, blue space, natural areas and landscape; or performing activities using materials sourced from nature or in connection with nature in indoor settings) that are prescribed by a clinician or other qualified personnel. Studies of NBIs that were not explicitly prescribed by a healthcare professional, but where participants were recruited from any of the relevant settings (e.g. studies inviting participants directly through community organisations) were included only if they adopted an RCT design and were specifically targeted at older adults. Multicomponent interventions were included if reports clearly stated a green element/nature-based element was part of the intervention.
Comparator	Usual care, no intervention (e.g. waitlist control), or any other intervention.
Outcomes/ **E**valuation	Primary outcomes include overall health and wellbeing, psychosocial outcomes (mental healthdepression, anxiety, stress, self-esteem, loneliness, social isolation), and functional outcomes (physical activity, sensory and cognitive function). Secondary outcomes include anthropometrical and physiological indicators relevant to health outcomes of the review (e.g. cardiovascular or metabolic risk factors including weight, waist circumference, and body mass index [BMI]) and health outcomes (e.g. stroke, heart attack).
Language	English
Publication	Inclusion: full-text and completed studies. Exclusion: studies published only as abstracts as they do not report sufficient details for appropriate assessment.

2.3 Search strategies

Searches were developed and carried out by an Information Specialist on: MEDLINE, PsycINFO, ASSIA (Applied Social Sciences Index and Abstracts), GreenFILE, Web of Science and Dimensions from 2000 – October 2024 to identify published studies in English language. We searched the literature from 2000 onwards as our scoping of the literature indicated that research on the referral of non-medical prescriptions involving NBIs only started to emerge in early 2000s. Grey literature was searched via Overton and Google. Published protocols were checked to identify the main publications for completed

studies. They were ran on 29th and 30th October 2024. The search strategy is available in the Supplementary Files (Appendix 5). Search results were managed and de-duplicated in EndNote 20. Titles and abstracts were exported into Covidence to facilitate the subsequent reviewing process. [26]

2.4 Study screening and selection

Two reviewers independently screened titles and abstracts to identify potentially relevant studies. The full texts of relevant studies were retrieved for further assessment against the pre-specified inclusion/exclusion criteria (Table 1) by two reviewers. Disagreements were resolved by discussion or referral to a third reviewer.

2.5 Data extraction

We developed and piloted (21 studies) a data extraction template form in Covidence. Data extraction was initially undertaken by two reviewers and extracted data were compared and discussed to ensure consistent approaches between reviewers. Data extraction was subsequently carried out by one reviewer and checked by a second reviewer. Discrepancies were resolved by discussion or referral to a third reviewer. The following data were extracted from each study: first author, date of publication, study location, design, setting, details of intervention based on the TiDiER checklist [27]comparison group, sample size, participants' characteristics (including social determinants according to PROGRESS-Plus), methods of analysis, reported outcome measures, outcome assessment methods and results, and PPIE. Where reported, we planned to extract data on the level of deprivation at the level of the study or participants based on measures such as the Index of Multiple Deprivation or other neighbourhood or individual-level socio-economic indicators [28] however these data were rarely reported. The studies included a wide range of health and wellbeing outcomes, which were inductively classified by the research team into major outcome categories as shown in Supplementary Files, Appendix 6. For continuous outcomes, median (interquartile range) or mean (SD) change over time for each intervention arm, and between-group difference was extracted (including 95% confidence interval and/or p-value). For binary or categorical outcomes n and % meeting outcome criteria were extracted for each intervention arm, as well as risk difference or risk ratio.

2.6 Risk of bias assessment

We used the Mixed Methods Appraisal Tool (MMAT) to assess the methodological quality (0 to 5*) in both quantitative, and mixed methods studies [29], [30]. The appropriate MMAT checklist was used, depending on the design of the study. Assessment was undertaken by two independent reviewers, with disagreements resolved by discussion or a third reviewer. MMAT scores were used to assess risk of bias for quantitative designs [30], with a score of 4* or 5* indicating low risk of bias (high quality), a score of 3* moderate risk of bias or quality, and a score of 1* or 2* high risk of bias (low quality). This is a result of how many "yes" responses both reviews had both given for each question.

2.7 Evidence synthesis

Effectiveness of nature-based interventions

Evidence tables were generated to summarise study characteristics and risk of bias of included studies, as well as corresponding tables presenting study results, separately for 4 types of nature-based interventions: (i) activities in nature; (ii) green space exercise, (iii) horticultural interventions, and (iv) indoor gardening. Studies were grouped based on study design: RCTs, quasi-experimental or other comparative designs; and single arm (before-after) designs. Extracted outcomes were inductively classified into the following outcome domains: wellbeing and quality of life, mental health, physical health, physical activity, cognitive function, psychological outcomes, social outcomes, spiritual outcomes, and physiological or anthropometric outcomes.

For data extracted from comparative designs (RCTs or pseudo-experimental studies) an approach informed by GRADE [25] was used as a transparent approach to summarizing the evidence of effectiveness across studies for each outcome domain, and to grade the certainty of evidence. Summary of findings tables were constructed for the four types of nature-based interventions presenting certainty of evidence for each outcome domain. High certainty evidence required consistent findings with sufficient precision from multiple high quality RCTs. Evidence was downgraded if there was only one comparative design and, additionally, based on concerns related to study limitations (majority of studies had a high risk of bias), inconsistency (heterogeneity of study findings in terms of direction or magnitude of effect), or imprecision (small sample size, wide confidence intervals, or inadequate reporting of effect estimates). Findings from single-arm (before-after) designs were described to provide additional information, but findings were not included in the grading of evidence, as not providing sufficient evidence of effectiveness.

We originally planned to calculate summary estimates of effect for comparable outcomes, but the heterogeneity of included studies regarding participants, interventions, comparators and outcome measures meant that a meta-analysis was not considered appropriate. The heterogeneity between included studies and scarcity of data also prevented us from conducting planned sub-group analyses in relation to different age groups (studies in older vs. younger adults within the age range); studies that reported different levels of deprivation (high vs low); different areas or regions (urban areas vs. rural areas; Europe vs America vs Asia vs Australasia); and sensitivity analyses to assess the influence of risk of bias [28][[24]

2.8 Patient and public involvement and engagement (PPIE)

We engaged with public contributors including service users who had experience in receiving and utilising NBIs, a GP, and service providers who have been involved in running a GHP related organisation and/or leading GHP related activities. We followed the ACTIVE Framework guidance to inform PPIE activities in systematic reviewing [31]. Our PPIE members involved and engaged with this research in the following ways:

- **Influencing**: Commenting on and advising about studies included in the review, thereby directly shaping the review process (e.g. data extraction, resolution of uncertainties, and data interpretation).

- **Contributing**: Providing reflections and feedback that indirectly informed the review process, including the interpretation and reporting of findings.
- **Receiving**: Receiving information about the review process and its results.
- **Critiquing**: Commenting on the applicability of study findings to real-world contexts.
- **Sense-checking**: Reviewing and validating our presentation and interpretation of findings.

We followed the GRIPP2 reporting checklist to report the organisation and impact of PPIE in this review (Supplementary Files, Appendix 4) [32].

3. Results

3.1 Search results

The search identified a total of 12,520 unique publications, which underwent independent title and abstract screening by two reviewers. Following this, 230 publications were left for full text screening, where a further 189 publications were excluded. The main reasons for exclusion were publications that did not have an element of green space or natural environment within the interventions, had a population under 50 years of age, did not evaluate an intervention or were conducted in multiple settings unless data from the settings were reported separately, or concerned abstracts. A total of 41 studies were eligible for the wider evidence review where 7 studies had mixed-methods design, of which 21 reported data on effectiveness of GHP or NBIs. to be appraised and synthesised in this review. The PRISMA flow diagram can be found in Fig. 1 below.

3.2 Characteristics of included studies

The 21 included intervention studies comprised 11 randomised controlled trials (RCTs) including one cluster-RCT and two pilot trials, seven quasi-experimental, non-randomised controlled designs, and three single-arm (before-after) designs. The studies evaluated activities in nature (six studies) [33], [34], [35], [36], [37],[38], exercise interventions in green spaces (three studies) [39], [40] [38], indoor gardening (four studies) [14],[41], [42], [43], and/or horticultural therapy (nine studies) [44], [45], [46] [47], [48], [49], [50], [51], [52]. One study with two active intervention and one control arm is included under two categories (activities in nature and green space exercise) [38]. Study participants were referred to the intervention by a health or care professional via a 'prescription' in only four studies. [34], [37], [39], [50] For detailed study characteristics, see Supplementary Files, Appendix 7.

3.3 Quality appraisal

MMAT scores ranged between 0 and 5, with risk of bias (RoB) assessed as low for 12 studies, moderate for 5 studies, and high for 4 studies (see Supplementary Files, Appendix 8). Our assessments highlight various methodological strengths and weaknesses across different study designs. Within studies of RCTs, randomisation was often concealed, but a lack of blinding was common among outcome

assessors. Most non-randomised studies included participants representative of the target population and appropriate measurements, with limitations mainly related to incomplete outcome data and limited accounting for confounders.

3.4 Effectiveness of GHP and nature-based interventions

Activities in nature

A total of six studies [37–41, 44] [33], [34], [35], [36], [37], [38] involving 270 participants evaluated nature prescriptions. These comprised two randomized controlled trials (RCTs), two quasi-experimental studies, one mixed-methods quasi-experimental crossover study, and one mixed-methods single-arm pre–post design study. The nature prescription interventions were highly heterogeneous and included forest therapy, blue space exposure, wetland walks, and general nature prescriptions. Comparator groups also varied widely, ranging from urban walking groups, indoor relaxation activities, and exercise groups to printed educational materials. This diversity in both intervention and control arms contributed to significant methodological heterogeneity, making direct comparisons between studies challenging.

Appendix 9 (Supplementary files) includes data for all extracted outcomes including reported changes within groups following intervention change and effect estimates (between-group difference), where reported. Despite variability, some patterns emerged across the included studies. Improvements compared with control were observed in quality of life, anxiety, and social functioning in participants with various long-term conditions. However, results were inconsistent for systolic blood pressure and depression, and no significant differences compared to control were found for other measures of mental health (positive or negative affect). Notably, one study found that participants in an indoor relaxation control group reported greater reductions in fatigue than those in a nature walking group among individuals receiving post-cancer treatment, suggesting that non-nature-based interventions may also confer benefits. One single-arm design [37] contributed to a broader understanding of feasibility and potential benefits but added limited weight to the certainty of evidence due to lower methodological rigour.

The certainty of evidence ranged from moderate to very low across health and wellbeing outcomes (see Table 2). Evidence for most outcomes was considered of low or very low certainty, primarily due to imprecision with sample sizes typically fewer than 50 participants per arm. Study limitations also contributed to uncertainty, especially for measures of mental health, with two studies (Kolster 2023 and McCaffrey 2011), both rated as moderate risk of bias [34], [38]. A key reason for downgrading was the limited number of studies per outcome, with most outcomes assessed by a single study, reducing confidence in the reliability of effect estimate.

Table 2
Summary of findings (GRADE) - Activities in nature (6 studies: 2 RCTs, 3 pseudo-experimental, 1 before-after design)

	Study design and sample size		**Study findings**	**GRADE**	
Outcome	**Study design**: number of controlled and single arm designs (risk of bias)	**Sample size of controlled designs**: Total N (range) at baseline	**Between-group effect size (ES)** Detailed results in Appendix 9	**Certainty of evidence** Downgrades	**Conclusion (summary statement)**
Wellbeing and quality of life					
Quality of life	1 quasi-exp (low RoB) ([35])	N = 56	Greater improvement for forest therapy compared to educational materials in quality of life: **p < 0.001**, ES not reported.	**Very low** 1 study only, inconsistency, imprecision	Forest therapy may improve QoL in older people, but evidence is based on one study only, in people with hypertension.
Mental wellbeing	3 quasi-exp (2x low, 1 moderate RoB) *1 single arm* *(low RoB)* [36] [34] [35] [37]	N = 156 (21 to 79)	- Greater improvement for forest therapy compared to educational materials in wellbeing: **p < 0.001**, ES not reported - Greater improvement for blue-space activities compared to control (indoor relaxing) for wellbeing: **p = 0.04**, ES not reported - No significant difference between nature-based activities and an exercise programme in wellbeing: p = 0.17, ES not reported.	**Moderate** Imprecision	Different types of nature prescription may improve wellbeing in older people with long-term health conditions, although effects were not significant when compared to an active control (exercise).

	Study design and sample size		Study findings	GRADE	
Mental health					
Perceived mental health	1 quasi-exp (moderate RoB) [34]	N = 79	Significant improvement in mental health in those receiving a nature prescription, but not in those receiving exercise; between-group analysis not conducted.	**Very low** 1 study only, inconsistency, risk of bias, imprecision	There is insufficient evidence for the effect of nature prescriptions on perceived mental health in older people with poor health.
Depression	2 RCTs (1 low, 1 moderate RoB) 1 quasi-exp (low RoB) [33, 36, 38]	N = 119 (21 to 59)	- Greater improvement for forest therapy compared to similar activity in urban environment in depression scores: **p < 0.001**, ES not reported - No significant differences between walking in nature and other activities for improvement in depression scores: p = 0.09, ES not reported - No significant differences for blue space interventions compared to indoor control for improvements in depression: p = 0.86, ES not reported.	**Low** Inconsistency, imprecision	Evidence, based on small studies, shows inconsistent findings for the effect of various forms of nature prescriptions on symptoms of depression in people with physical or mental health conditions.

Table 2: **Summary of findings (GRADE) - Activities in nature (6 studies: 2 RCTs, 3 pseudo-experimental, 1 before-after design)**

Green space exercise

Three studies, all RCTs [39], [40], [38] evaluated green space exercise interventions, with a total of 221 participants. The studies demonstrated substantial heterogeneity in both intervention types and comparator arms. Interventions included park prescriptions, group or independent walking, guided imagery, and art therapy, while control conditions varied, including usual care and indoor exercise. Study findings for all outcomes are summarized in Supplementary files, appendix 10.

Across the included studies, there was limited evidence of effectiveness for the reported outcomes. One study [40] reported significant reductions in diastolic blood pressure and physical exhaustion for an outdoor rehabilitation programme compared to an indoor programme offered to nursing home residents, but effects were only measured immediately after the session. The small number of studies per outcome - often only one - combined with considerable heterogeneity in intervention type and delivery, and lack of long-term follow-up limits the certainty of reported effects.

The certainty of the evidence (**see** Table 3), assessed using the GRADE approach, ranged from low to very low across all outcomes. Evidence for most outcomes were downgraded due to imprecision, primarily stemming from small sample sizes and the fact that most outcomes were informed by data from only one RCT. Risk of bias further contributed to downgrading of evidence for most outcomes, with only one RCT considered low risk of bias [40]. Systolic blood pressure was the only outcome graded as low certainty, informed by two RCTs [39] [40], but with both studies reporting small and non-significant differences between green space exercise compared to usual care (adjusted mean difference 0.5 mmHg (95% CI − 2.9 to 3.0) [39] or indoor exercise (standardised mean difference, Cohen's D: 0.28 (p = 0.532) [40]. All other outcomes, including wellbeing, quality of life, mental health, physical activity, physical function, and physiological or anthropometric measures were graded as very low certainty due to insufficient evidence, low precision, and study limitations.

Table 3
Summary of findings (GRADE) – Green space exercise (3 RCTs)

Anxiety	**1 RCT (low RoB),** **1 quasi-exp (low RoB),** ***1 single arm*** ***(low RoB)*** **[33, 36, 37]**	**N = 80** **(21, 59)**	**- Greater improvement for forest therapy compared to similar activity in urban environment in anxiety scores: p < 0.001, effect size not reported** **- Greater improvement in anxiety scores for blue-space activities, incl. snorkelling and beach bathing compared to control (indoor relaxing): p = 0.02, ES not reported**	**Moderate** **Imprecision**	**Evidence, based on small studies in older people with long-term health conditions, indicates that various forms of nature prescriptions may reduce symptoms of anxiety.**
Stress	*1 single arm* [37]	N = 16	One single-arm design: Significant improvement (p = 0.04) for a wetland nature-based intervention in perceived stress		Insufficient evidence
Positive affect	1 RCT (moderate RoB), *1 single arm* *(low RoB)* [37, 38]	N = 39	No significant difference between walking in nature and other activities in improvement of scores for positive emotion: p-value and ES not reported	**Very low** 1 study only, inconsistency, imprecision	There is insufficient evidence for the effect of walking in nature on measures of positive affect, compared to art therapy in older people with depression.
Negative affect	1 RCT (moderate RoB), *1 single arm* *(low RoB)* [37, 38]	N = 39	No significant difference between walking in nature and other activities in improvement of scores for negative emotion: p-value and ES not reported	**Very low** 1 study only, inconsistency, imprecision	There is insufficient evidence for the effect of walking in nature on measures of positive affect, compared to art therapy in older people with depression.
Psychological outcomes					

Fatigue (mental)	1 quasi-exp (low RoB) [36]	N = 21	Greater improvement in fatigue scores for some blue-space interventions, but also for control (indoor relaxing) compared with walking: **p = 0.01** and **p = 0.03**, ES not reported.	**Very low** 1 study only, inconsistency, imprecision	Control (indoor relaxing), bathing and snorkelling may reduce fatigue compared to walking, but evidence is based on one study only, in people following cancer treatment.
Social outcomes					
Overall social dimensions	1 quasi-exp (low RoB) *1 single arm* *(low RoB)* [70]	N = 56	Greater improvement in social dimension of quality of life questionnaire for forest therapy compared to educational materials: **p < 0.001**, ES not reported.	**Very low** 1 study only, inconsistency, imprecision	Forest therapy may improve social outcomes in older people with hypertension, but evidence is based on one study only.
Physiological/anthropometric					
Systolic BP	2 quasi-exp (low RoB) [36] [35]	N = 77 (21, 56)	- No significant differences in improvement of systolic blood pressure between blue space activities and control (indoor relaxation): p = 0.20, ES not reported - Greater improvement in systolic blood pressure immediately after forest therapy compared to educational activity: **p = 0.03**, ES not reported No difference at 8 weeks follow-up (p = 0.46).	**Low** Inconsistency, imprecision	Evidence, based on small studies, show inconsistent effects of various forms of nature prescriptions on systolic blood pressure in older people with long-term health conditions.
Diastolic BP	2 quasi-exp (low RoB)	N = 77 (21,56)	- No significant differences in improvement of diastolic blood	**Moderate** Imprecision	Evidence, based on small studies, indicates that various forms of

	[36] [35]		pressure between blue space activities and control (indoor relaxation): p = 0.78, ES not reported - No significant difference in systolic blood pressure immediately after forest therapy compared to educational activity or at 8 weeks: p = 0.34, ES not reported.		nature prescriptions may not significantly reduce diastolic blood pressure in older people with long-term health conditions.
Sleep	2 quasi-exp (1 low, 1 moderate RoB) [36] [34]	N = 100 (21, 79)	- No significant differences in improvement of sleep quality between blue space activities and control (indoor relaxation): p = 0.62, ES not reported - Similar significant improvements in total sleep time and quality of sleep in those receiving a nature prescription as well as in those receiving exercise, between-group analysis not conducted.	**Moderate** Imprecision	Evidence, based on small studies, indicates that various forms of nature prescriptions may not significantly improve measures of sleep time or quality in older people with long-term health conditions.

Table 3: **Summary of findings (GRADE) – Green space exercise (3 RCTs)**

1. Indoor Gardening

A total of four studies [14], [41], [42], [43], all considered low risk of bias, investigated indoor gardening interventions, comprising two randomized controlled trials (RCTs) and two quasi-experimental, non-randomised studies involving 310 participants (nursing home residents and community-dwelling older people) in total. Comparators included usual care, routine care, indoor occupational activities, and traditional activities. Details regarding the effects of indoor gardening on health and wellbeing outcomes are presented in the Supplementary files, Appendix 11.

The evidence from the included studies suggest that indoor gardening interventions may improve overall quality of life, depression, loneliness, and social network in nursing home residents. These effects were reported in both RCTs and one quasi-experimental study, regardless of variability in study design and intervention delivery. However, findings related to other outcomes, such as depression and sense of coherence, were less consistent or did not reach statistical significance compared to control, limiting confidence in these effects.

The certainty of evidence (see Table 4) across all outcomes was either moderate or very low. Moderate-certainty evidence was found for improvements in overall quality of life and loneliness. While indoor gardening generally showed improvements in these outcomes compared to usual care, only one study [14] reported effect estimates of between-group differences, limiting the interpretability of study findings. The evidence was downgraded for imprecision, as all studies had fewer than 50 participants per arm, and several outcomes were informed by one study only.

Table 4
Summary of findings (GRADE) - Indoor Gardening (4 studies: 2 RCTs, 2 quasi-experimental designs)

	Study design and sample size		**Study findings**	**GRADE**	
Outcome	**Study design**: Number of controlled and single arm designs (risk of bias)	**Sample size of controlled designs**: Total N (range) at baseline	**Between-group effect size (ES)** Detailed results in Appendix 10	**Certainty** downgrades	**Conclusion (summary statement)**
Wellbeing and Quality of Life					
Overall Wellbeing	1 RCT (high) [39]	160	No significant difference between park prescription and usual care for - SF12: adjusted mean difference: -0.1 (95% CI: -0.3, 0.2), p = 0.631 - WHO5: adjusted mean difference: -1.0 (95% CI: -6.9, 4.8), p = 0.727	**Very Low** 1 study only, inconsistency, risk of bias	There is insufficient evidence to suggest that green exercise significantly improves general health or wellbeing in healthy older people, though this is based on 1 RCT.
Mental Health					
Depression	1 RCT (moderate) [38]	39	No significant differences between walking in nature and other activities in improvement of depression scores: p = 0.09, ES not reported	**Very Low** 1 study only, inconsistency, risk of bias, imprecision	There is insufficient evidence to suggest that green exercise significantly improves depression, though this is based on 1 RCT.
Distress	1 RCT (high) [39]	160	No significant difference between park prescription and usual care for distress scores: adjusted mean	**Very Low** 1 study only, inconsistency, risk of bias	There is insufficient evidence to suggest that green space exercise significantly improves distress

	Study design and sample size		Study findings	GRADE	
			difference: -0.7 (95% CI: -1.9, 0.6), p = 0.277		in healthy older people, though this is based on 1 RCT.
Positive Affect	1 RCT (moderate) [37, 38]	39	No significant difference between walking in nature and other activities in improvement of scores for positive emotion: p-value and ES not reported	**Very Low** 1 study only, inconsistency, risk of bias, imprecision	There is insufficient evidence to suggest that green space exercise significantly improves positive affect compared to control in older people with depression, though positive affect improved in all arms, and this is based on only 1 study.
Negative Affect	1 RCT (moderate) [37, 38]	39	No significant difference between walking in nature and other activities in improvement of scores for negative emotion: p-value and ES not reported	**Very Low** 1 study only, inconsistency, risk of bias, imprecision	Based on 1 study there is insufficient evidence to suggest that green space exercise significantly improves negative affect compared to control in older people with depression, though negative affect improved in all arms.
Physical Activity					
Physical Activity	1 RCT (high) [39]	160	Variable findings for physical activity in one trial comparing park prescription with usual care, adjusted mean difference: - 10 min bouted MPVA:	**Very Low** 1 study only, inconsistency, risk of bias	There is insufficient evidence to suggest that green space exercise improves MPVA compared to usual care. A significant increase in PA conducted in a park was found, but based on 1

	Study design and sample size		Study findings	GRADE	
			0.6 (95% CI: -46.5, 47.6), p = 0.981 - Total MVPA: 130.2 (95% CI: -129.1, 389.5), p = 0.323 - Minutes physical activity per week: 190.3 (95% CI 59.7, 320.9), **p = 0.005**		RCT in healthy people.
Active engagement in PA	1 RCT (low) [35]	22	No significant difference between outdoor versus indoor rehabilitation exercise in engagement with physical activity: Cohen's d = 0.43, p = 0.529	**Very Low** 1 study only, inconsistency, imprecision	There is insufficient evidence to suggest that green space exercise improves engagement in PA, though there were improvements in both arms and this is based on one RCT in nursing home residents.
Physical Function					
Physical exhaustion (fatigue)	1 RCT (low) [40]	22	Greater improvement for outdoor versus indoor rehabilitation exercise in physical exhaustion (fatigue): Cohen's d = 1.76, **p = 0.035**	**Very Low** 1 study only, inconsistency, imprecision	Green space exercise may be significantly more beneficial for physical fatigue compared to indoor exercise, however this is based on one RCT only in nursing home residents.
Physiological/anthropometric					
Systolic BP	2 RCTs (1 low, 1 high) [39, 40]	182 (22–160)	- No significant difference between park prescription and usual care in systolic blood pressure:	**Low** Risk of bias, imprecision	There is insufficient evidence to suggest that outdoor exercise improves systolic BP compared to

	Study design and sample size		Study findings	GRADE	
			adjusted mean difference: 0.5 (95% CI: -2.9, 3.9), p = 0.770 - No significant difference between outdoor versus indoor rehabilitation exercise in systolic blood pressure: Cohen's d = 0.43, p = 0.529		usual care or indoor exercise in older people.
Diastolic BP	2 RCTs (1 low, 1 high) [39, 40]	182 (22–160)	- No significant difference between park prescription and usual care for diastolic blood pressure: adjusted mean difference: -0.4 (95% CI: -2.8, 2.0), p = 0.727 - Greater improvement for outdoor versus indoor rehabilitation exercise in diastolic blood pressure: Cohen's d = 0.36, **p = 0.008**	**Very Low** Risk of bias, inconsistency, imprecision	There is mixed evidence regarding the effect of green exercise on diastolic BP in older people. No significant difference between arms when compared to an inactive control, but a significant difference was found when compared to indoor exercise.
BMI	1 RCT (high) [39]	160	No significant difference between park prescription and usual care in body mass index: adjusted mean difference: -0.3 (95% CI: -7.0, 0.0), p = 0.074	**Very Low** 1 study only, inconsistency, risk of bias	There is insufficient evidence to suggest that green space exercise significantly improves BMI in healthy older people, though this is based on one RCT only.

	Study design and sample size		Study findings	GRADE	
Outcome	**Study design**: Number of controlled and single arm designs (risk of bias)	**Sample size of controlled designs**: Total N (range) at baseline	**Between-group effect size (ES)** Detailed results in Appendix 11	**Certainty** downgrades	**Conclusion (summary statement)**
Wellbeing and Quality of Life					
Overall quality of life	2 quasi-exp (2 low Rob) [42, 43]	N = 66 (13, 53)	- Greater improvement (8 weeks) for indoor gardening sessions compared with usual care for life satisfaction score: **p < 0.001**, ES not reported - Indoor horticulture appears to improve (6 weeks) self-satisfaction scores compared with indoor occupational activity (cross-over design), but mean scores and ES could not be extracted.	**Moderate** imprecision	Indoor gardening may improve overall quality of life compared to baseline or usual care in nursing home residents. However between group differences were not reported in one study, which had an active control.
Depression	1 RCT (low RoB) [41]	N = 150	- Greater improvement for indoor horticultural activity compared to routine care for depression score: GEE β (mean difference over 8 weeks) -7.240, SE =	**Low** 1 study only, inconsistency	Indoor horticultural activities may improve depression in nursing home residents; however this is based on only one RCT, with no effect size presented.

	Study design and sample size		Study findings	GRADE	
			0.4776, **p < 0.001**		
Loneliness	1 RCT 1 quasi-exp (2 low RoB) [41, 42]	N = 203 (53, 150)	- Greater improvement for indoor horticultural activity compared to routine care for UCLA loneliness score: GEE β (mean difference over 8 weeks) -9.680, SE = 1.861, **p < 0.001** - Greater improvement (8 weeks) for indoor gardening sessions compared with usual care for UCLA loneliness score: **p < 0.001**, ES not reported	**Moderate** imprecision	Indoor gardening may improve loneliness compared to usual care in nursing home residents, though one included study was small.
Social					
Social Network	1 quasi-exp (low RoB) [42]	N = 53	Greater improvement (8 weeks) for indoor gardening sessions compared with usual care for social network score: **p < 0.001**, ES not reported.	**Very Low** 1 study only, inconsistency, imprecision	Indoor gardening may improve social networking compared to usual care in nursing home residents, however this is based on one small study.
Social Network (Sociability)	1 quasi-exp (low RoB) [43]	N = 13	Similar improvements reported for sociability (desire to socialise) at 6 weeks for indoor	**Very Low** 1 study only, inconsistency, imprecision	Insufficient evidence to suggest that indoor gardening significantly improves sociability

	Study design and sample size		Study findings	GRADE	
			horticulture and indoor occupational activity (cross-over design), but mean scores and ES could not be extracted.		compared to indoor occupational activities in nursing home residents, based on one small study.
Spiritual					
Sense of Coherence	1 RCT (Low RoB) [14]	N = 92	Greater improvement for indoor desktop gardening compared to traditional activities for sense of coherence scores, especially in the longer term, but difference across time-points (baseline, 4, 8, 12 weeks) was not significant: GEE Wald β = 0.24 (SE 0.13), p = 0.071.	**Very Low**1 study only, inconsistency, imprecision	There is insufficient evidence to suggest that indoor gardening significantly improves sense of coherence compared to control, based on one cluster-RCT in nursing home residents.
Physical Function					
Activities of Daily Living	1 quasi-exp (Low RoB) [42]	N = 53	Neither indoor gardening nor usual care improved activities of daily living (Barthel Index) at 8 weeks, differences between arms were not significantly different: p = 0.06, ES not reported.	**Very Low** 1 study only, inconsistency, imprecision	There is insufficient evidence to suggest that indoor gardening may improve activities of daily living, based on one small study in nursing home residents.
Cognitive Function					
Concentration	1 quasi-exp (Low	N = 13	Both indoor horticulture	**Very Low**	There is insufficient

	Study design and sample size	Study findings	GRADE	
	RoB) [43]	and occupational activity (cross-over design) improved concentration (6 weeks), with no significant differences: p-value and ES not reported.	1 study only, inconsistency, imprecision	evidence to suggest that indoor horticultural activities may improve concentration in nursing home residents, based on one small study. However, concentration improved in both indoor horticultural and indoor occupational activities.

Table 4: **Summary of findings (GRADE) - Indoor Gardening (4 studies: 2 RCTs, 2 quasi-experimental designs)**

Horticultural Interventions

A total of nine studies [44], [45] [46] [47], [48], [49], [50] [51], [52] evaluated the effectiveness of horticultural interventions in older adults, comprising five RCTs (including two pilot RCTs), two quasi-experimental studies, and two single-arm pre–post designs. These studies collectively included 504 participants including community-dwelling older adults or people living in residential care (with or without dementia). There was marked heterogeneity across studies, both in the nature of the interventions and the control conditions. Comparator arms included waitlist control, usual care, structured exercise programs, health education, and social activities without a horticultural component. Details regarding within-group change and treatment effect are described in Appendix 12, Supplementary Files.

Across most outcomes, horticultural interventions demonstrated insufficient evidence of effectiveness in improving key domains such as wellbeing and quality of life, cognitive function, psychological health, mental health, spiritual wellbeing, and physiological measures. For outcomes where more than one RCT was available, the findings were often inconsistent, and effect sizes (where reported) were generally small or not statistically significant.

The only outcomes for which statistically significant differences were reported concerned self-efficacy and self-esteem, social connectedness, and activities of daily living. Perkins et al. 2011 [47] showed small improvements in self-efficacy and self-esteem in the horticulture intervention arm, compared with a larger reduction reported in the wait list control arm. In addition, both Ng et al. [51] and Yao et al. 2017

[48] reported significant benefits for measures of social connectedness compared with usual care or waitlist control, although effect size was not reported. Yao et al. [48] also reported a significant increase in activities of daily living in nursing home residents compared with the control group receiving usual care. The two single-arm pre–post studies [49], [50] provided limited additional insight due to the lack of a comparator group, and their findings (significant improvements in life satisfaction, mental well-being and sleep), must be interpreted with caution.

The overall certainty of the evidence for horticultural interventions (**see Table 5**) was rated as low to very low across all reported outcomes. Two RCTs were assessed as having a low risk of bias, resulting in downgrading of evidence for most outcomes. As for the other types of nature-based interventions, imprecision or absence of multiple studies was the most important reason for downgrading evidence across outcome measures.

Table 5: Summary of findings (GRADE) - Horticultural Interventions (9 studies: 5 RCTs [including two pilot RCTs], two quasi-experimental, and two single-arm pre–post designs)

4. Discussion

4.1 Main findings

We found low certainty evidence to support the benefits of GHP and nature-based interventions for improving quality of life, mental health, self-esteem, fatigue, physical function, loneliness, and social connectedness, but positive effects were not consistently observed across studies. The certainty of evidence was considered low or very low for most outcomes due to high risk of bias, small sample size, and the fact that many outcomes were informed by data from one study only. Many studies only assessed short-term outcomes, measured immediately after the end of the session or programme.

Only a small number of studies considered older people living in deprived areas [53], [54], [55], [56], [57], however, regarding unequal access to green space and difficulty in taking part in nature-based activities, there is not enough evidence to support that this may specifically affect older people from disadvantaged backgrounds.

4.2 Interpretation of findings in the context of previous research

There is a rapidly growing body of evidence evaluating the use of GHP and nature-based interventions (not limited to older age) [58], [59] [60], [58], [61], and a broader literature evaluating the role of social prescribing to reduce the impact of unmet social needs, support the delivery of personalised care, and reduce healthcare resource use in older people [62], [63]. Previous systematic reviews suggest that there are positive effects but have also cautioned about high levels of heterogeneity and risk of bias in intervention studies [58], [64], [65]. Two recent meta-analyses included a larger number of studies with participants of any age and reported significantly reduced symptoms of depression and anxiety

following horticulture activities [58], [64], [65]. These reviews indicate that nature-based interventions have the potential to benefit mental health across the lifespan. Previous research has also highlighted the importance of integrating nature with physical activity to benefit both physical and mental health [66], yet our review identified only three, mostly small low-quality studies, investigating green space exercise interventions tailored to older people. [60] Our review highlights a clear gap in the literature emphasising the need for robust evaluation of nature-based interventions in older adults with long-term conditions for whom GHP is increasingly considered.

Despite a lack of strong evidence for the effectiveness of GHP on health and wellbeing outcomes in older people, the data indicated that nature-based interventions may foster social connectedness and increase motivation and confidence. This likely supports sustained participation in nature-based programmes and longer-term adoption of healthy lifestyle behaviours. Similar findings were reported in a previous systematic review evaluating the effects of nature-based interventions on psychological well-being in people with long-term conditions [67]. Loneliness has recently been identified by the World Health Organisation as a global health challenge, emphasizing the need for practical, scalable solutions to strengthen social connection [7]. GHP and group-based interventions in nature may potentially offer such a solution.

4.3 Limitations of included research

In our review of the effectiveness of GHP and nature-based interventions, many of the included intervention studies reported non-significant effects on measures of health and wellbeing when compared with other active interventions or wait-list controls. Most studies were characterised by small sample sizes and limited statistical power to detect meaningful differences; intervention durations were frequently short, and follow-up was typically restricted to assessments conducted shortly after intervention completion. Several additional considerations merit attention. First, in only four of the 21 effectiveness studies was the intervention clearly prescribed by a health professional. Individuals referred to nature-based interventions through healthcare services may differ in important ways from those who self-select to participate without formal prescription. This limits the applicability of the existing evidence when considering the potential benefits of GHP delivered as part of preventive healthcare for older people. Second, although all included nature-based interventions shared a common focus on engagement with nature, there was substantial heterogeneity in the activities undertaken, the settings in which they occurred, and the methods through which they were organised and delivered. Most intervention studies examined the health effects of a specific form of nature-based intervention, and in some cases within narrowly defined populations (e.g. care home residents with dementia, cancer survivors). This further constrains the applicability of the review's findings to GHP as implemented within real-world health services for older people, who present with a wide range of health conditions and for whom intervention options are often tailored to individual needs, capabilities, and preferences.

4.4 Strengths and limitations

Strengths of this review include its broad scope, synthesising evidence on the effectiveness of all types of nature-based interventions; a systematic literature search that included grey literature; rigorous assessment of risk of bias across study designs; a robust narrative synthesis; and the involvement of both service users and providers to help bridge gaps between effectiveness evidence and real-world implementation. The review forms part of a broader evidence synthesis that also evaluated qualitative evidence on the barriers and enablers of access to and the uptake and delivery of GHP and NBIs among older people, submitted separately.

This review was conducted during a period of rapid expansion in social prescribing activities worldwide. Although the search strategy was comprehensive, constraints related to time and resources meant that additional search approaches, such as reference checking or citation tracking, were not undertaken to identify further studies. As a result, some relevant studies may have been missed. We had planned to examine the use and impact of GHP for older people, with particular attention to those living in deprived areas; however, very few studies reported detailed information on socioeconomic factors or presented data relating to disadvantaged populations.

4.5 Stakeholder involvement and implications for policy and practice

Public contributors with lived experience of Green Health Prescribing (GHP), alongside service providers involved in prescribing, designing, and delivering nature-based interventions, were involved throughout the review process. Contributors were engaged in shaping the review plans, interpreting findings, and contextualising the evidence. Although the review identified limited and inconclusive evidence from trials regarding the effectiveness of GHP, public contributors consistently reported positive impacts on their mental and physical health based on their lived experience. They emphasised the importance of connection with nature, social interaction, and a sense of meaning and purpose derived from participation in nature-based activities. Contributors also highlighted spiritual and psychosocial aspects of GHP that they felt were not adequately captured by commonly used outcome measures, particularly for older people. In addition, they underscored the value of green outdoor environments in facilitating social interaction and strengthening community cohesion compared with traditional clinical settings. Co-developing a logic model [68] with contributors supported identification of key components, mechanisms, and outcomes of GHP programmes, helping to inform priorities for future research and implementation as investment in GHP continues [18].

4.6 Implications for research

Current evidence is clearly lacking rigorous evaluations of GHP as an option for preventative healthcare for older people with long-term conditions compared with existing or alternative health service provision. Van den Berg, in an opinion article, concludes that the transitioning from providing green spaces to green prescriptions must rely heavily on robust clinical and basic research as well as holistic evaluation [69]. The author also noted reluctance of healthcare professionals to prescribe nature-based interventions, which is supported by findings from our qualitative evidence synthesis identifying barriers to GHP [68].

Such holistic research, which could take the form of cluster/stepped wedge trials or other implementation designs, should address barriers in prescribing, access, uptake and delivery of nature-based interventions in primary and community care settings. However, GPs in Scotland are aware of and willing to refer to GHP but have concerns about accessibility for patients from deprived areas [19]. Evaluation of GHP at service level (rather than at the level of a specific type of intervention) will align better with the core characteristic of GHP and social prescribing as person-centred care, increasing the validity and applicability of findings.

Conclusions

Our review presented evidence from a systematic review of 21 studies. Four types of nature-based interventions were identified: (i) activities in nature; (ii) green space exercise, (iii) horticultural interventions, and (iv) indoor gardening. Studies were grouped based on study design: RCTs, quasi-experimental or other comparative designs; and single arm (before-after) designs.

Overall, our evidence synthesis shows evidence of benefit of nature-based interventions on quality of life, mental health and social outcomes in older people. However, the evidence is characterised by inconsistency, varying quality and imprecision, making it difficult to draw firm conclusions regarding the benefits of GHP and specific types of nature-based interventions (activities in nature, green space exercise, indoor gardening, horticultural interventions) for improving health and well-being outcomes in older adults. Our review has highlighted the need to clarify the costs and benefits or effectiveness of GHP at service level through holistic and robust health services research designs.

Abbreviations

GHP: Green Health Prescribing

NBIs: Nature Based Interventions

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SWIM: Synthesis without a meta-analysis

GRIPP2: Guidance for Reporting Involvement of Patients and the Public version 2

PPI-E: Patient and Public Involvement and Engagement

GP: General Practitioner

MMAT: Mixed Methods Appraisal Tool

Declarations

Ethics approval and consent to participate

Ethics approval and consent are not applicable for this review

Consent for publication

Not applicable

Availability of data and materials

The datasets supporting the conclusions of this article is included within the article and its additional files

Competing interests

The authors declare that they have no competing interests

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Authors’ contributions

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JD: Protocol development, screening and selection, data extraction, quality appraisal, qualitative synthesis, writing and editing.

CL: Screening and selection, data extraction, quality appraisal, editing, reviewing drafts.

ND: Protocol development, developing and conducting searches, editing, reviewing drafts.

SS: Conceptualisation, protocol development, oversight PPIE and stakeholder involvement, reviewing drafts

LAK: Conceptualisation, protocol development, reviewing drafts

TMS: Data extraction, quantitative evidence synthesis, editing, reviewing drafts.

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HF: Conceptualisation, protocol development, reviewing drafts

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Table 5

Table 5 is not available with this version.

Figures

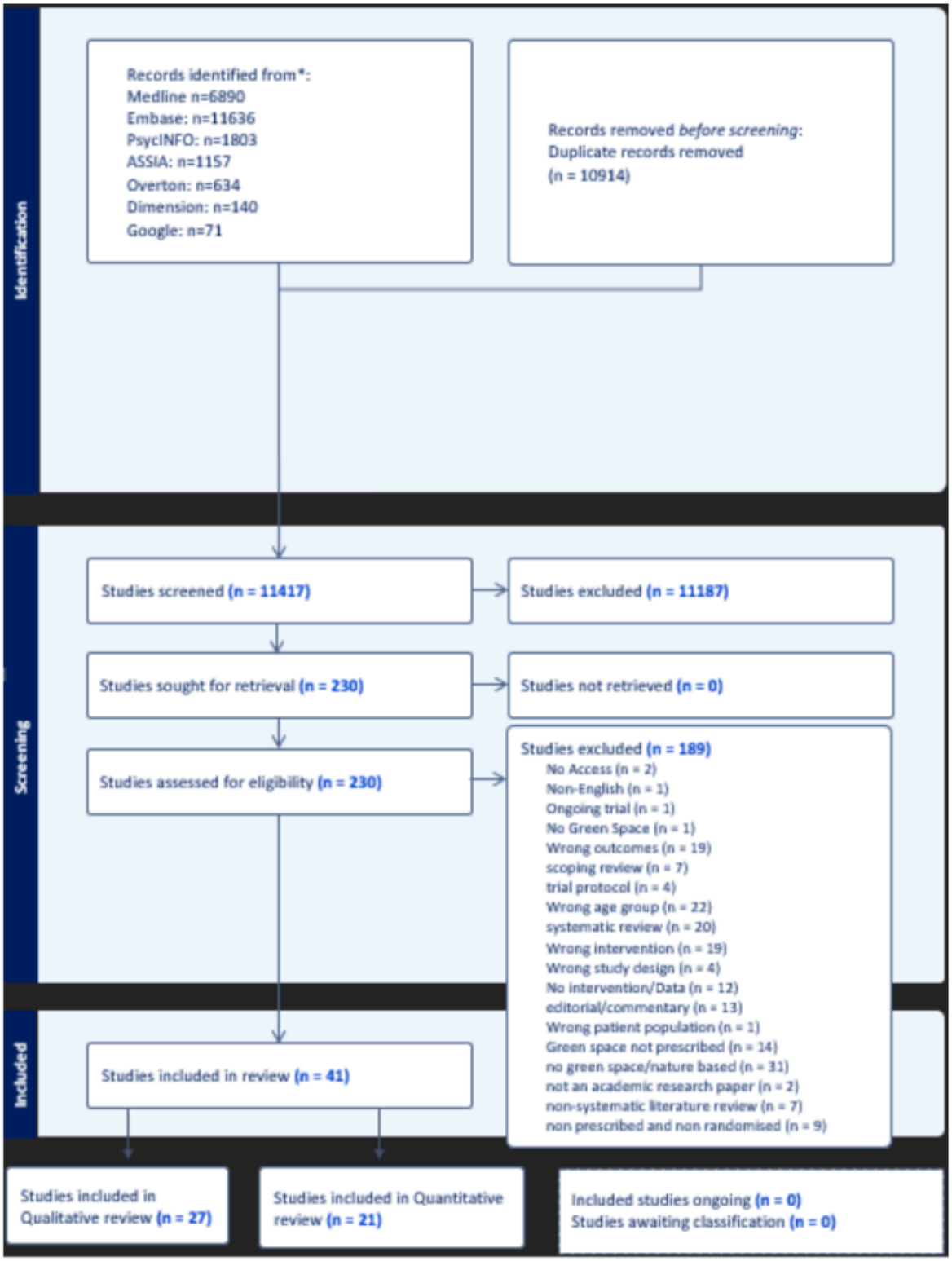


Figure 1

PRISMA Flowchart

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