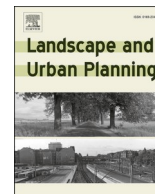




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Connecting through nature: A systematic review of the effectiveness of nature-based social prescribing practices to combat loneliness

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HIGHLIGHTS

- We reviewed 38 articles on how nature-based group interventions affect loneliness.
- Quantitative studies had small sample sizes and small or moderate effects.
- Qualitative studies showed more clearly how these interventions reduce loneliness.
- Group-based activities including natural elements cultivate connectedness and belonging.
- Longer interventions showed greater promise in reducing loneliness.
- Linking landscape with public health promotes and amplifies the value of urban nature.

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ABSTRACT

Loneliness is increasingly recognized as an urgent public health issue due to its impact on mental and physical health, and well-being. Yet, we lack comprehensive, proven strategies for confronting this global problem. There is evidence that contact with nature and greenspace reduces loneliness by facilitating belonging, social connections, and social cohesion. This review aimed to explore whether such positive outcomes can be enhanced via group-based interventions in nature. We used a mixed-methods systematic review approach to evaluate and characterize literature on nature-based social interventions for their effectiveness in reducing loneliness. We included all age groups, in populations with or without reported health problems. Using the Mixed Methods Appraisal Tool, we assessed the quality of included qualitative, quantitative and mixed methods studies. The 38 studies identified describe a wide variety of interventions and target groups. The quantitative studies included mostly small sample sizes with small or moderate effects. The qualitative studies, however, showed more clearly that these interventions can reduce loneliness. Group-based activities including natural elements cultivated connectedness and belonging, which are key mechanisms to reducing loneliness. Specifically, longer interventions showed greater promise. Policy and practice recommendations include loneliness screening, the need to describe loneliness more precisely, and the need to evaluate intervention effectiveness over time. This review provides perspectives to inform policymakers, urban planners, and researchers on how group-based interventions

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in nature can alleviate feelings of loneliness. By linking landscapes with public health concerns, municipalities can further promote and amplify the value of urban nature to the public.

1. Introduction

Humans are built for social connection, yet we are experiencing a new epidemic of loneliness (Office of the Surgeon General, 2023; The Global State of Social Connections, 2023). Although primarily based on studies from the US and Europe, the emerging evidence base highlights the global nature of the problem (Lippke & Warner, 2023). Approximately one-third of people in industrialized countries identify as lonely, with 1 in 12 experiencing loneliness at levels known to be harmful to individual mental health and physical wellbeing (Surkalim et al., 2022). Loneliness is an urgent public health issue due to its impacts on longevity, well-being and health (Murphy, 2023). The experience of loneliness arises from a perceived lack in the quantity and quality of desired relationships (Jansson & Pitkälä, 2021). Internationally, governments, policy makers, and service providers are exploring new and innovative ways to facilitate social connection and promote well-being through nature (Holt-Lunstad, 2022). Despite recent developments of interventions to tackle loneliness, we lack sufficient evidence on their efficacy (O'Rourke et al., 2018).

Contact with nature is emerging as a solution to address loneliness. For example, evidence suggests that increases in the time spent in nature during the COVID-19 pandemic eased the experience of loneliness (Soga et al., 2021). This adds to a growing evidence base demonstrating the positive effect of greenspaces on mental health and loneliness (Larson et al., 2022). Developing research shows that spending time in natural settings may motivate and support social bonding, social cohesion, and openness towards social relationships (Goldy & Piff, 2020; Oh et al., 2022). For example, the presence of trees or green space near one's home has been associated with greater trust in neighbors and increased neighborhood social cohesion (Holtan et al., 2015; Kuo et al., 1998). Feeling a connection to nature has been associated with greater perspective taking—seeing the world from others' points of view (Goldy & Piff, 2020; Mayer & Frantz, 2004). A field study found that participants sitting in a park for 5 min increased feelings of interconnectedness with a world larger than oneself (Neill et al., 2019). Furthermore, individuals in laboratory nature conditions such as resting in a room with plants (Weinstein et al., 2009) or viewing a nature film (Zelenski & Nisbet, 2014) displayed more generous behavior towards others than participants in control groups.

A referral to groups in natural settings is one approach to social prescribing. Social prescribing is an innovative, non-clinical intervention that may facilitate social connection and improve individuals' mental health and wellbeing (Litt et al., 2023a). Through social prescribing, individuals are linked to community activities which aim to facilitate social connection and promote good health (Muhl et al., 2023). It targets the root causes of disease by motivating behavior change. It is rapidly becoming part of national health policies (Lee et al., 2023). Linkages between healthcare providers and social programs represent a holistic strategy for confronting persistent health inequities, addressing unmet psychosocial needs, and reducing health care office visits (Leavell et al., 2019). Recent reviews have explored the impact of social prescription on loneliness (Reinhardt et al., 2021), mental health (Cooper et al., 2022), community wellbeing (Vidovic et al., 2021), and on service users more generally (Pescheny et al., 2020).

Through nature-based social prescribing (NBSP), care professionals refer people experiencing loneliness or poor mental health to social activities in natural settings that can improve their health and wellbeing (Litt et al., 2024; Santos-Tapia et al., 2023). People lacking social connection may be referred, for example, to local walking groups or community gardening and food-growing projects (Garside et al., 2020). The efficacy of NBSP or other nature-related interventions for

facilitating social connections and reducing loneliness is not well understood. In contrast to systematic reviews exploring the efficacy of social prescribing for reducing loneliness, no equivalent systematic review of nature-based social prescribing, referral, or therapy for loneliness exists. Recent systematic reviews have explored the broader impact of nature prescriptions on health and wellbeing (Kondo et al., 2020; Nguyen et al., 2023). However, they lacked a distinct focus on loneliness. A related health review by Adewuyi and authors captured exclusively randomized controlled trials of green prescriptions (Adewuyi et al., 2023). Several scoping reviews have focused on the benefits of particular nature-based programs, including horticultural therapy in promoting wellbeing for people in long-term living facilities (Noone et al., 2017), gardening on wellbeing (Howarth et al., 2020), and green space for mental disorders (Wood, Wicks, & Barton, 2023). Additionally, a recent systematic review explored the effect of green space on loneliness (Astell-Burt et al., 2022), however authors did not include a prescription or intervention focus in the search. Cumulatively these reviews provide a patchwork of evidence relating to health and nature-based interventions, but do not explore the effectiveness of nature-based social activities as solutions to the growing loneliness epidemic.

This paper examines the current state of evidence for nature-based social interventions for loneliness delivered through prescriptions, referrals, or therapeutic programs. We conducted a broad and systematic review of published literature (quantitative, qualitative, and mixed methods) to explore the efficacy of nature-based group intervention studies. We describe the study populations as well as components and quality of group-based interventions that affected loneliness and its related outcomes such as social isolation, alienation, or social connectedness. This review can inform urban planners, researchers, and policymakers on how group-based interventions in natural settings may alleviate feelings of loneliness across diverse social and cultural groups and ages.

2. Methods

This systematic review is part of the RECETAS project, which is dedicated to evaluating the effectiveness of NBSP in six cities worldwide (Coll-Planas et al., 2024; Litt et al., 2024). The review was registered to the International Prospective Register of Systematic Reviews in March 2023, id CRD42023407011. It follows the reporting guidance provided in the Adapted PRISMA for reporting systematic reviews of qualitative and quantitative evidence (Page et al., 2021).

2.1. Scope of review

The selection criteria followed the PICOS (Population, Intervention/Exposure, Comparison, Outcomes and Study design) framework (Higgins & Thomas, 2023).

- 1. Population:** Individuals of all ages and backgrounds
- 2. Intervention:** To be eligible for our review, interventions had to specifically integrate nature into their intervention while also being group-based. Interventions may have included a spectrum of nature exposures, including outdoor activities as well as indoor activities. Studies additionally needed to meet the criteria of NBSP, referral, program, rehabilitation, or therapy. Studies could not be a cross-sectional survey of individuals in a given area who had not been part of an intervention or program with others.
- 3. Comparator:** Any intervention study design that met the eligibility criteria was included. For controlled studies, the comparison was

expected to be usual care, or a control group, although, we did not exclude studies on this basis.

4. **Outcomes:** Measured or examined experiences or perceptions of loneliness, social isolation, alienation, or connectedness.
5. **Study designs:** We included both quantitative and qualitative primary research designs. For qualitative studies to be eligible, results describing outcomes related to loneliness or social connectedness outcomes were needed. Quantitative studies were eligible if they included measurable loneliness-related outcomes in relation to nature-based group interventions.

2.2. Search strategy

The authors conducted a systematic review and have provided a report in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. A professional systematic review librarian developed, translated, and executed a search string in the following databases: MEDLINE (via PubMed), Embase (Elsevier), PsycINFO (ProQuest), Environment Complete (via EBSCO), ClinicalTrials.org (via website), and Web of Science (via Clarivate). The string included a mix of keywords and subject headings representing 'loneliness', 'nature/outdoors', and 'prescribing/therapies'. No restrictions were placed by date or language. Editorials and comments were excluded. Reproducible search strategies can be found in **Table A** appendix. The original search was executed on June 1, 2022, and an update of the search was performed on November 11, 2022, and April 10, 2023.

2.3. Study inclusion criteria

Studies were eligible for full-text review if they: (i) had full texts published or translated into English; (ii) measured or examined experiences or perceptions loneliness (Jansson & Pitkälä, 2021), social isolation (Zavaleta et al., 2017), alienation (Jaeggi, 2014), or connectedness (O'Rourke et al., 2018); (iii) described nature-based prescribing, referral, program, rehabilitation, or therapy; (iv) were original research (quantitative and qualitative) or grey literature (proceedings, government agencies reports, academic research briefs). Conference papers, literature reviews, commentaries, and perspective pieces were also inspected for context.

We excluded studies from full-text review if they: (i) were abstracts only; with no full text available; (ii) did not explore loneliness or social isolation or related constructs; (iii) involved prescription, therapy, or referral, but did not involve nature-based activities; (iv) did not provide clear health outcomes or evidence about loneliness, social isolation, alienation, or comparatively: social connectedness outcomes; or (v) were general articles discussing the health benefits of nature.

2.4. Screening and data extraction

COVIDENCE® software (Veritas Health Innovation, n.d) was used for all data analysis with twelve independent reviewers. The data extraction and quality assessment templates were piloted by JG and VP and adapted after discussion in the research group. Two independent reviewers reviewed each item in title and abstract screening as well as full-text review, with a non-reviewer resolving conflicts in these sections. Similarly, independent reviewers conducted the quality assessment of full texts and data extraction, including information on authorship, year of the study, funding sources, country, population, nature-based activity characteristics, study design, loneliness outcome measurement, and main findings [see **Table B** appendix] with a non-reviewer resolving conflicts. Coauthors did not review, extract, or assess papers they personally published.

2.5. Quantitative data synthesis

The quantitative data were compiled from the extracted data by AK and checked for accuracy by VP. As the concluded results revealed significant heterogeneity in populations, study-design, and outcome measurements, we performed a systematic narrative synthesis of the results. The populations were clearly demarcated in three distinct categories, which are: 1) youth or university students, 2) adults with poor mental health and 3) geriatric populations. Within these groups, the outcomes were diverse.

2.6. Qualitative data synthesis

In qualitative studies, NO, MH, and NH performed an analysis of the study designs, aims, and outcomes as reported by the authors. The data were organized into categories, themes, and subthemes to identify key patterns. The initial reviewer, NO, conducted an inductive analysis to generate these categories, themes, and subthemes. The accuracy and consistency of the analysis were then verified by two additional reviewers, MH and NH, who reviewed and validated the identified categories, outcomes, and sub-outcomes. The mixed methods studies were integrated in the results and analyses as quantitative or/and qualitative as appropriate but reported separately.

2.7. Quality appraisal of selected studies

Mixed Methods Appraisal Tool (MMAT) Version 2018 was used to assess the quality of included qualitative, quantitative (including randomized controlled trials, nonrandomized and descriptive studies) and mixed methods studies (Hong et al., 2018). The qualitative, quantitative and mixed methods categories were judged depending on the study design. Each category had five criteria and were rated with "Yes", "No", or "Cannot tell" by two reviewers and consensus was achieved via an independent, third reviewer. The quality score was calculated by adding the number of questions answered positively. Individual scores ranged from 0* (0 % of the quality criteria met) to 5***** (100 % of the quality criteria met). For mixed methods studies, the quality of the weakest component represents the overall quality (Hong et al., 2018). Systematic reviews were excluded from the review as they did not conform to our inclusion criteria. They informed the discussion, as outlined within our study protocol.

3. Results

3.1. Study selection

Searches yielded a total of 12,465 citations across all databases. All citations were imported into COVIDENCE® software (Veritas Health Innovation, n.d.). Duplicate citations ($n = 5,990$) were automatically identified and removed using Covidence. Twelve independent reviewers screened references ($n = 6,475$) by title and abstract excluding articles that did not align with screening criteria ($n =$ screened 6,331). All conflicts regarding eligibility were resolved between reviewers or, if unresolved, by adjudication by an additional reviewer. The full texts ($n = 144$) were assessed by ten independent reviewers with an eleventh to resolve disagreements and exclude irrelevant studies ($n = 106$). Some studies were excluded during the full-text review that appeared to fit our study criteria but did not after full text review. For example, a walking study in the COVID-19 pandemic did not measure loneliness (Bonnell et al., 2022) and an urban intervention to increase nature-based features lacked a group-based aspect (Semenza & March, 2009). Data from the final included studies ($n = 38$) were extracted by ten authors. Study selection is presented by flowchart as per PRISMA 2020 guidelines (Page et al., 2021) in Fig. 1.

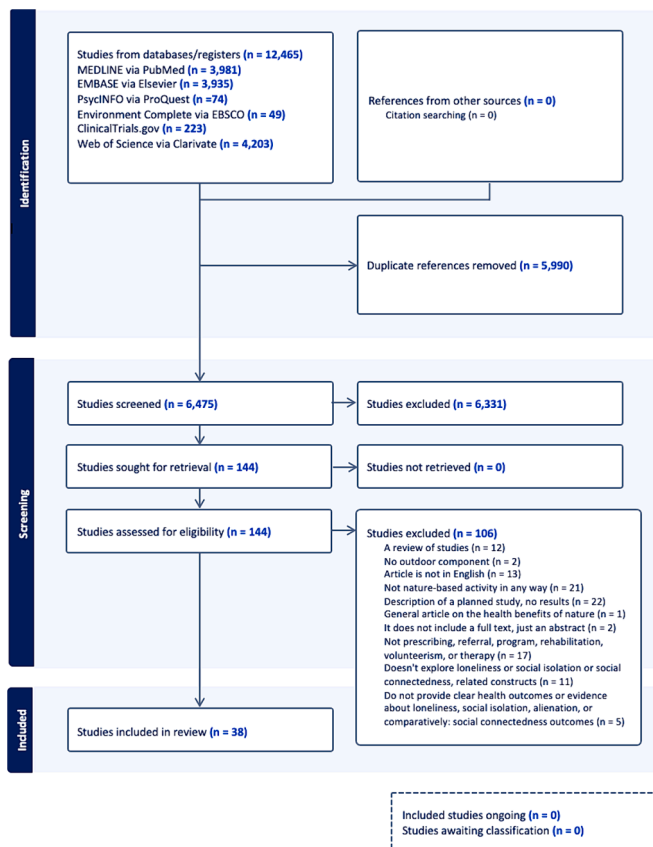


Fig. 1. PRISMA flow diagram via COVIDENCE.

3.2. Study characteristics and quality

The study design, quality outcomes, and study characteristics including population and interventions are reported in **Table B** appendix with main outcome measures. Of the mixed methods studies, four used quantitative outcomes for loneliness. The outcomes of the remaining two mixed methods were not incorporated in the quantitative results as they lacked clear quantitative loneliness outcomes.

We examined thirteen qualitative and six mixed methods studies according to the NBSP activity and explored corresponding outcomes and sub-outcomes. Qualitative methods included direct observation, semi-structured interviews, focus groups, photo voice, surveys, diary entries, audiovisual recordings as well as exploratory case studies. The results of studies without a clear intervention are presented separately in Section 3.5.3.

3.3. Intervention characteristics

We reviewed papers to extract and categorize the type of nature-based activity performed. This resulted in three distinct types of activities. These categories were also identified within our quantitative study review. Categories and corresponding studies are outlined in **Table 1**.

Nature-based physical activities: Exercise or physical activity outside in a natural setting. Many activities included interacting with natural landscapes including forests, parks, beaches, or mountains. Both exercise and leisure activities that made use of and engaged with nature were eligible.

Natural element: A particular context or activity that included elements of the natural world. To foster a sense of connection with nature, it incorporated natural components into a setting, experience, or a study design.

Gardening-based interventions: Therapeutic horticulture or

Table 1
Intervention characteristics.

Category	Studies
Nature-based physical activities	Four qualitative (Brown, Smarinsky, McCarty, & Christian, 2022; Irvine et al., 2022; Khan, 2020; Wilkie, Arroyo, Conibeer, Kemp, & Fisher, 2021); three quantitative (Cross, 2002; Levinger et al., 2020; Rodriguez-Romero et al., 2021) and one mixed methods study (Barclay et al., 2018). Examples: mountain biking, adventure therapy, outdoor walking, a climbing camp, an outdoor gym.
Natural element	One quantitative (Kotera & Fido, 2021) two qualitative (Jin & Son, 2018; Salazar & Heyman, 2014), and two mixed methods studies (Maund et al., 2019; Sachs et al., 2022a). Examples: summer camps, meditative forest therapy, nature focused activities on wetlands and mindfulness nature-based social interventions.
Gardening-based interventions	Seven qualitative (Fielder & Marsh, 2021; Fieldhouse, 2003; Freeman et al., 2022; Howarth, McQuarrie, Withnell, & Smith, 2016; Labbé, Miller, & Ng, 2019; Milligan, Gattrell, & Bingley, 2004; Stein, 2022) seven quantitative (Fan et al., 2022; Lin et al., 2020; Meore et al., 2021; Mourao, Mouro, Brito, Costa, & Almeida, 2022; Sempik, Rickhuss, & Beeston, 2014; Tse, 2010; Wood, Barton, & Wicks, 2022); and three mixed method studies (Chen & Ji, 2015; Howarth et al., 2018; Thomson, Morse, Elsdon, & Chatterjee, 2020). Examples: community gardening, cultivation of native crops, hydroponic tower care, drying teas, gardening and house plant care, fresh food production and contact with animals. Three of the garden-based interventions occurred indoors. Two studies combined three-dimensional virtual reality and gardening activities, and another was an indoor gardening program.

rehabilitative activities with gardening for improved social, emotional, mental, and physical health.

3.4. Description of outcomes and impact of interventions

3.4.1. Loneliness, social isolation, social connectedness constructs and measures

Loneliness was assessed in most studies alongside other health outcomes. Few studies primarily targeted loneliness. Self-reported measures were mostly used, although in some studies measures were recorded by facilitators according to group needs (Sempik et al., 2014). **Table 2** provides an overview of quantitative measures reporting loneliness outcomes.

Most qualitative studies were exploratory. Some used evaluative approaches to examine the subjective experiences of NBSP on social isolation and loneliness. Loneliness related quantitative measures were diverse. They reflected a range of subjective indicators such as social connection, loneliness, social isolation, and related outcomes such as social relationships, quality of life, social bonding, place identity and place dependence.

3.4.2. Measuring intervention effectiveness

In our narrative synthesis of intervention outcomes, stronger reductions in loneliness were reported in studies involving longer follow-up periods. However, we cannot conclude the processes by which these interventions affect loneliness due to the diversity of populations, interventions, and overall study quality. Intervention effectiveness is presented according to population. As part of this, participant recruitment and adherence is noted. Adherence is understood as the level of activity attendance and completion. Outcome measure, intervention type and duration and study quality are compiled in **Table B** appendix.

Within studies targeting youth, undergraduate students had the highest loneliness scores at baseline, indicating moderate to severe loneliness (Kotera & Fido, 2021). No significant change was noted

Table 2
Quantitative loneliness construct measures.

Scale	Brief description	Interpretation	Reference
UCLA Loneliness Scale	Items: 20 Levels: 1–4 Range: 20–80	Higher scores indicate greater loneliness	Russell, 1996
UCLA-3 Loneliness Scale	Items: 3 Levels: 1–3 Range: 3–9	Higher scores indicate greater loneliness. No agreed upon cutoff score	Matthews et al., 2022
Lubben Social Network Scale (LSNS)	Items: 6 / 12 Levels: 0–5 Range: 0–30 / 0–60	Higher scores indicate more social engagement	Lubben, 1988
Dean's Alienation Scale	Items: 24 Levels: 1–5 (Strongly Agree, Agree, Uncertain, Disagree, Strongly Disagree) Range: 24–120	Higher scores indicate higher levels of alienation	Dean, 1961
De Jong Gierveld Loneliness Scale	Items: 11 Levels: 5 ("yes!", "yes", "more or less", "no", "no!") Range: 0–11	Higher scores indicate greater loneliness	de Jong-Gierveld & van Tilburg, 1999
Social and Emotional Loneliness Scale for Adults Short Version (SELSA-S)	Items: 15 Levels: 1–7 (1 = Strongly Disagree to 7 = Strongly Agree) Range: 15–105	Higher scores indicate greater loneliness. Includes dimensions of social loneliness, family loneliness and romantic loneliness	DiTommaso et al., 2004

following this 3-day intervention or at the 14-day follow-up. Another shorter intervention examined the benefits of rock climbing for adolescents from an alternative school (Cross, 2002). Qualitative analysis of participants' diaries showed decreased feelings of alienation among participants in the climbing intervention, but not in the control group. The Meeting in Nature Together program targeted loneliness among teen parents and their peers (Sachs et al., 2022a). Recruitment and adherence challenges related to COVID19 lockdowns during the 2020–21 academic year were noted, as the program completion rate declined from 75% in 2020 to 33% in 2021.

Therapeutic horticulture activities were the most common nature-based interventions involving adults and older adults. Mourao and colleagues compared the effects of therapeutic horticulture to conventional occupational therapy among institutionalized clients with mental health conditions (Mourao et al., 2022). Although no overall difference in loneliness outcomes were reported between the intervention and control participants, larger numbers of days per week with activities decreased the loneliness and increased the happiness perspective within the therapeutic horticulture group. Regression analysis for both groups indicated that 14% of the variability in happiness perspective compared to peers depended on the sum of participants' social, family, and romantic loneliness subscales.

A study by Meore and others included US veterans with a history of suicidal intentions (Meore et al., 2021). Participants rated their perceived stress, pain, mood, and loneliness before and after therapeutic horticulture sessions. Pre-session scores for meetings 2–4 were lower compared to those at baseline. The sustained effect size using Cohen's *d* showed medium effects for loneliness (-0.51).

The longer therapeutic horticulture programs largely involved participants suffering with mental illness. Sempik et al. (2014) reported a positive change in social interaction over the course of one year, significant from three months onward. The small increase in social interaction (effect size 0.38; $p = 0.033$) for all participants remained significant at one year. The effect size (effect size 0.65) was highest at six months ($p = 0.019$). Participants with learning disabilities showed significant increases in social interaction only after one year of

participation in therapeutic horticulture activities (effect size 0.82; $p = 0.014$). This fluctuation can partly be attributed to random variation. It may also suggest that fostering social connection and reducing loneliness takes longer for some cohorts.

Wood et al. (2022) reported that 57.8% of the participants considered social interaction to be the most important element of therapeutic horticulture. Different patterns and gender differences occurred. Emotional loneliness declined among women but increased among men. Social loneliness declined among men, but was stable among women. Howarth et al. (2018) identified improvements in social networks for 45% of therapeutic horticulture participants, but lacked supporting data.

Among older adults, a therapeutic horticulture program for psychosocial health reduced loneliness scores after ten weeks of participation ($p < 0.001$) (Chen & Ji, 2015). Within qualitative analysis, four categories were identified: social connection, anticipation and hope, sense of achievement, and companionship.

Three studies used an indoor garden intervention, all involving older adults in China or Taiwan. Lin et al. (2020) used a combination of three-dimensional virtual reality and therapeutic horticulture with institutionalized older adults. For loneliness, the experimental group did not show significance ($p = 0.44$). However, group \times time (experimental posttest vs control pretest) showed significance ($p < 0.001$). Fan et al. (2022) used a quasi-experimental design with three-dimensional virtual reality glasses and therapeutic horticulture. The intervention reduced isolation outcomes ($p = 0.002$), and generalized estimated equations found significance for improved self-esteem and mastery, but not isolation. Tse (2010) investigated the impact of an indoor gardening intervention, with significant improvements in social network noted. A significant decrease in perception of loneliness for the experimental group was reported with loneliness decreasing following the intervention ($p < 0.00$) compared to no change in control group. The social network score improved ($p < 0.00$) in the intervention group.

An exercise program conducted within older adult participants noted a significant reduction in loneliness (Levinger et al., 2020). Although loneliness was only mild-moderate at baseline, it reduced following the 12-week intervention ($p = 0.04$). But, after 9 months, the score was not statistically significantly different from baseline. Furthermore, social isolation did not change.

Our review yielded only one study explicitly targeting loneliness. Participants in this study by Rodríguez-Romero et al. (2021) were older adults with moderate-to-severe loneliness. Results reported decreased loneliness in the intervention group ($p < 0.001$). The loneliness score in the control group did not change. Six months after the intervention period, 48.3% did not feel lonely, compared to 26.9% in the control group. However, this study gained only 40% of the quality credits, and only two out of eighteen sessions were considered nature-based. Loneliness appears to have been scored nontraditionally via the UCLA scale, therefore the results may be unreliable.

3.4.3. Summary and integration of qualitative loneliness outcomes

Of the nineteen qualitative and mixed method studies identified, five involved nature-based physical activities, four contained natural elements, and ten examined gardening-based interventions (See Table 1). We examined the benefits outlined within each paper and grouped these into three main outcomes – *Connecting through gardening* ($n = 7$), *Physical activities in nature* ($n = 6$), and *Bonding in nature* ($n = 7$) (See Table 3). Due to the way qualitative findings are described within individual papers, some are included in more than one outcome. The outcomes and sub-outcomes listed below reflect the benefits derived from a range of nature-based activities, ways of interacting with nature, perceptions of well-being, social inclusion, and connectedness across diverse cohorts, such as age, chronic illness, social isolation, and disability.

Connecting through gardening highlights the meaning and value derived through community gardening and how the activity may promote interpersonal connections, support individual wellbeing and

provide a sense of purpose and personal fulfilment. The *Physical activities in nature* outcome provides insight into the way social activities in natural settings, including walking, cycling, or hiking activities promote social connection and facilitate a sense of belonging by providing opportunities for social encounters and the development of enduring relationships. The *Bonding in nature* outcome provides insight into the way natural environment can promote social connection and improve mental health and wellbeing. Moreover, natural settings provide chances for social contact, the forging of social connections, and the establishment of relationships.

3.4.4. Implementation and uptake of NBSP

Only a few studies identified in our search explored participant interest and NBSP implementation. For example, a study examined the interest of Australians in NBSP and whether it was needed (Astell-Burt et al., 2023). The recommended time spent in nature was 2 h/week. Using adjusted odds ratios (AOR) the study found that people who were lonely had a 24% lower chance for achieving this recommendation. The AOR for visiting favorite places at least once a week was 35% lower for those experiencing overall loneliness, 30% for those suffering from social loneliness and 40% lower if loneliness was emotional.

A pathway analysis identified in our search among Chinese older adults found that social engagement had a positive effect on cognitive function and loneliness had a negative effect on cognitive function (Mai et al., 2023). Outdoor activities in this study were ranked as the third most important social engagement activity influencing cognitive function.

Social restrictions during the COVID-19 lockdown provided research opportunities. The population survey by Stock and others found no longitudinal associations between number of days spent outside and loneliness during lockdown. Meanwhile, depressive and anxiety symptoms decreased with time spent outdoors (Stock et al., 2022). Measures indicated moderate participant loneliness during the study.

4. Discussion

Our review is one of the first to explicate the variety of nature-based social interventions that reduce loneliness. Our findings have implications globally, as poor mental health exacerbated by loneliness continues to rise (Hards et al., 2022). We found a diverse variety of nature-based social interventions used to reduce loneliness. The 38 publications demonstrate a modest evidence base representing their effectiveness for loneliness. The broad scope of the review, along with the limited quality of the studies and the diversity of study methodologies, populations, interventions, and outcome measures reduced our ability to draw definitive conclusions regarding the overall effect of the interventions. However, general themes across the studies were detected. The analysis provides rich detail about the impact that the nature-based social interventions had on individuals and their wellbeing.

Target groups were largely marginalized groups vulnerable to loneliness. Within the quantitative results, a stronger reduction in loneliness was found in studies with middle to longer duration. Loneliness was often measured alongside other measures of wellbeing, and mainly in populations with chronic health challenges. A range of themes relating to increased social connectedness such as the development of social networks, making friends, or feeling accepted and respected by peers were identified in qualitative studies.

4.1. Loneliness among seniors

Given its prevalence in all age groups, we expected to find a larger variety of research focusing on preventive programs and early-stage interventions in broader populations beyond typically isolated groups, such as geriatric patients. Although older adults were the most commonly represented in the studies reviewed, there is limited evidence about the ways in which age, loneliness, and nature-based social

Table 3
Outcomes and sub-outcomes identified within qualitative studies.

Outcomes	Sub-outcomes	Papers	
Connecting through gardening	- Deeper meaning and emotional experience in communal gardening activities	Milligan et al., 2004	
	- Allotments as relational spaces for overcoming social exclusion		
	- Developing social networks through community gardening		
	- Sense of connectedness through interacting with the environment	Chen & Ji, 2015; Freeman et al., 2022; Fielder & Marsh, 2021	
	- Improvement of quality of life and connectedness in communal garden sites for older people		
	- Therapeutic horticulture, improving confidence, skill-building and establishing relationships	Howarth et al., 2018; Thomson et al., 2020	
	- Increased feelings of well-being and psychological well-being		
	- Decreased social isolation		
	- Cultivation of native crops for connection to country of origin	Stein, 2022	
	- Sense of place, physical, social and psychological well-being		
	Physical activities in nature	- Collective connectedness and socialization in recreational leisure activities	Labbé et al., 2019
		- Appreciation of family and friends' involvement in activities	
- Sense of connectedness through acknowledging and interacting with the environment		Brown et al., 2022	
- Importance of socialization and socializing physical activities in the community		Khan, 2020	
- Sense of belonging and promotion of health and well-being		Howarth et al., 2016; Wilkie et al., 2021; Wilkie et al., 2021	
- Sense of community and social cohesion			
- Increased motivation to walk		Barclay et al., 2018	
- Perceived safeness when walking in a group			
Bonding in nature		- Building empathic and supportive relationships in disease-specific camps	Salazar & Heyman, 2014
		- Positive awareness of mental and emotional condition	Jin & Son, 2018
		- Reduced feelings of isolation and loneliness	
		- Improved health-related lifestyle	
	- Improved mental health, mental well-being, anxiety levels, stress and emotional well-being	Maund et al., 2019	
	- Improved physical health and reduced social isolation		
	- Spontaneous mixing and mingling	Irvine et al., 2022	
	- Evolving social experiences		
	- Individual social well-being achievements		
	- Pragmatic elements fostering engagement		
	- Unique contribution of occupational therapy to health promotion and social inclusion	Fieldhouse, 2003	
	- Enjoy connecting with other participants and feeling more calm and more connected to nature	Sachs et al., 2022a; Howarth et al., 2016	

interventions might relate to specific health outcomes. A pathway analysis found perceived loneliness played a mediating role between social engagement and cognitive function (Mai et al., 2023). However, dementia also inhibits social interaction, while loneliness is an independent risk factor for dementia in later life (Liu et al., 2020).

4.2. Loneliness among youth

Adolescent mental health has declined globally, partly due to the worsening of loneliness. Increasingly, research shows that young people have an increased risk for feeling lonely (Hards et al., 2022). This may be related to common changes taking place in self-identity and relationships with family and other social groups, and the transition towards greater personal independence (Sachs et al., 2022a). Social media could also play a role. In the USA, 98% of adolescents in a 2016 survey reported regularly using at least one social media site (Shannon et al., 2022). Higher levels of social media use are associated with loneliness (Griffiths et al., 2014).

Looking to nature-based solutions, there has been much attention devoted to children's declining relationship with nature, while the increasing time adolescents spend indoors has gone largely unnoticed. Few studies have explored why adolescents spend so much time on phones and with computer games, keeping them largely indoors, when they might be engaging outdoors in natural environments (Greenwood & Gatersleben, 2016). Our findings indicate that social, nature-based activities show promise in reducing youth loneliness. Four of the five studies with youth populations showed moderate to strong results for reducing loneliness.

4.3. Physical activity outdoors

Physical activity has abundant positive health effects and can improve social belonging (Brown et al., 2014). Being part of a group supports physical activity routines that can support a feeling of purpose and self-confidence (Adams & Morgan, 2018). This was reflected in our findings. The outdoor physical activity programs for seniors reduced loneliness, and the importance of social connections cultivated during physical activity was mentioned in feedback (Barclay et al., 2018; Levinger et al., 2020).

4.4. Therapeutic horticulture

Gardening is one of the most well-established green-space interventions (Litt et al., 2023b). It has been shown to reduce loneliness in various populations, including with new gardeners (Sachs et al., 2022b) and geriatric patients in aged-care settings (Quan et al., 2020). Three studies involved indoor horticultural activities (Fan et al., 2022; Lin et al., 2020; Tse, 2010) which did not include the potential benefits of being outdoors, including fresh air and the multi-sensorial activation (Hale et al., 2011). However, indoor nature-based activities may increasingly hold appeal for certain populations as extreme weather events make spending time outside a threat to some groups (Sprague et al., 2022).

4.5. Quality and characteristics of natural environments

The papers included in this review broadly did not explore the different qualities or the biodiversity of the natural environment. Although the gardening-based interventions captured participants' direct engagement with plants, many of studies included described "nature" as a uniform, background context. Whilst it is acknowledged that biodiversity in nature can boost human health (Cook et al., 2019), in general, we lack clarity on how human health is influenced by the presence or absence of biodiversity (Ulrich et al., 2023). Even more limited is the pool of research connecting biodiversity with mental wellness, or loneliness more specifically. However, different green space designs and nature experiences can deliver diverse benefits with respect to wellbeing (Marselle et al., 2021). For example, higher levels of species diversity in parks have been linked to improved mental wellbeing benefits (Cameron et al., 2020); different sensory experiences such as sounds, smells and tactile sensations have a variety of pathways to wellbeing (Franco et al., 2017). A deeper awareness of the potential of

biodiversity for human health can help to promote the creation and use of diverse urban spaces that encourage aesthetic appreciation, social connection, and ecological understanding.

4.6. NBSP feasibility and implementation

Our search included studies exploring feasibility of future NBSP programs (Barclay et al., 2018; Maund et al., 2019; Sachs et al., 2022a). These pilot studies underscore the novelty and timeliness of NBSP for loneliness as studies begin to scale, expand, and include control groups. Participants in these pilots reported high levels of satisfaction and interest in continuing to engage in the nature-based activities. However, target groups may be hesitant to join interventions. They often need support to participate (Husk et al., 2020). In one study, the interest in NBSP was lower for those experiencing loneliness than with those who were not (Astell-Burt et al., 2023). Conducting such field-studies is critical, as they provide realistic findings to aid in implementation.

4.7. Study strengths and limitations

To our knowledge, this is the first comprehensive systematic review of evidence exploring the association between nature-based social interventions and loneliness. By including quantitative, qualitative, and mixed methods studies, it provides a comprehensive understanding of how these interventions may alleviate loneliness. Each step of the systematic review involved PRISMA guidelines as well as a steering group of experts to ensure both rigor and relevance of the review process and findings.

Our findings support the theory of NBSP's ability to reduce loneliness. As with all systematic reviews, our study has several limitations. Firstly, the 38 papers may include a risk of positive bias. Studies with positive outcomes are more likely to be published and match the keywords used within our searches. Secondly, none of the studies had a rigorous control for following up regarding reasons for drop-out. Participants experiencing positive effects are more likely to stay in the interventions. Results display only the effects on those enjoying the interventions. Qualitative data did include themes related to adherence and participants' positive perceptions of the interventions. In future research, interviews with those who abandon health interventions would be useful, as feelings of not belonging can lead to drop-out.

Thirdly, the use of diverse outcome measures presented challenges for making comparisons across intervention studies and evaluating their effectiveness in reducing loneliness. Short, validated questionnaires were useful in population studies (Astell-Burt et al., 2023; Stock et al., 2022). Including validated questions of loneliness in future population-based studies primarily targeting other health outcomes could give a deeper understanding of its prevalence and meaning. Furthermore, a more precise definition of the dimensions, or types, of loneliness could help design interventions that empower participants (Jansson, Karisto, & Pitkälä, 2022). No included studies introduced calculations of intervention cost-effectiveness. This analysis is critical to scaling up and funding future NBSP strategies.

Finally, our review is restricted to English language literature. Limitations also depend on included studies that include small sample sizes, diverse populations, and different durations of follow up. This makes it hard to provide a precise answer to our research question, regarding the effectiveness of nature-based group interventions for loneliness. Future studies could perform a more focused meta-analysis of scores from specific measures to advance this topic.

4.8. Policy and practice recommendations.

Based on our findings that almost all papers included marginalized populations with limited follow-up, we recommend expanded, earlier surveillance for loneliness in healthcare settings and beyond. Loneliness is a part of life, but it can have considerable health implications (Holt-

Lunstad, 2017). A targeted public campaign to increase literacy around the health and wellbeing impacts of loneliness and green infrastructural solutions may improve uptake of NBSP and ensure early intervention—preventing serious comorbidities in the longer term.

As demonstrated in our results, change in the negative feeling of loneliness can occur slowly for some groups. Adequate support as well as considering long term interventions is important for treatment settings. Digital platforms could be a helpful way to overcome the challenges of maintaining involvement in activities (Litt et al., 2024). We consider NBSP a safe and feasible method potentially improving physical activity and emotional health. It warrants further testing and evaluation.

The planning and health sectors must work together when developing urban landscapes for social and health purposes. These types of health-promoting interventions are dependent on cities developing greenspaces that encourage social connection. Linking landscapes with urgent health needs is another way for municipalities to promote and amplify the importance and value of urban nature to the public.

5. Conclusion

This systematic review shows modest evidence that nature-based social interventions have the potential to reduce feelings of loneliness. Specifically, there is some evidence that middle to longer interventions showed greater promise with potentially reducing loneliness, and that group-based activities may cultivate connectedness and belonging. When scaling nature-based loneliness interventions and cultivating interest, we must actively engage more-isolated cohorts who may benefit the most. NBSP is an innovative strategy for building community while leveraging urban green spaces. Policy and practice recommendations should include earlier loneliness screening, promotion of nature-based activities for social connection, targeting a more precise type of loneliness, and a concerted effort to include intervention follow-up. By linking landscapes with public health concerns, municipalities can further promote and amplify the global value of urban nature.

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CRedit authorship contribution statement

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Declaration of competing interest

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

Data availability

This is a systematic review, and no data was created for this paper.

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Appendices

- A: Full search strategies for all databases.
- B: Results from data extraction and quality assessment

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.landurbplan.2024.105071>.

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