Indoor Nature Interventions for Health and Wellbeing of Older Adults in Residential Settings: A Systematic Review

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Abstract

Background and Objectives: Having contact with nature can be beneficial for health and wellbeing, but many older adults face barriers with getting outdoors. We conducted a systematic review of quantitative studies on health and wellbeing impacts of indoor forms of nature (both real and simulated/artificial), for older adults in residential settings.

Research Design and Methods: Search terms relating to older adults and indoor nature were run in thirteen scientific databases (MEDLINE, CINAHL, AgeLine, Environment Complete, AMED, PsychINFO, EMBASE, HMIC, PsychARTICLES, Global Health, Web of Knowledge, Dissertations and Theses Global, and ASSIA). We also pursued grey literature, global clinical trials registries, and a range of supplementary methods.

Results: Of 6131 articles screened against eligibility criteria, 26 studies were accepted into the review, and were quality-appraised using the Effective Public Health Practice Project (EPHPP) tool. The participants were 930 adults aged over 60. Nature interventions and health/wellbeing outcomes were heterogeneous, which necessitated a narrative synthesis. The evidence base was generally weak, with 18/26 studies having a high risk of bias. However, several higher quality studies found indoor gardening and horticulture programmes were effective for cognition, psychological wellbeing, social outcomes and life satisfaction.

Discussion and Implications: There is inconsistent evidence that indoor nature exposures are beneficial for older care residents. We expect that successful interventions were, at least partly, facilitating social interaction, supporting feelings of autonomy/control, and promoting skill development, i.e. factors not necessarily associated with nature *per se*. Higher quality studies with improved reporting standards are needed to further elucidate these mechanisms.

Keywords

Nature, Intervention studies, Residential Care, Wellbeing, Indoor Environment

Background and Objectives

In the UK in 2018, around 421,000 adults aged 65+ were living in residential homes (Age UK, 2017). Despite the benefits of 24-hour access to professional staff and presence of a network of other residents, transitioning into and living well within long-term care can present significant challenges for some residents; with greater risk of dissatisfaction, loneliness, hopelessness and depression accompanying declines in physical and cognitive health as people age (NICE, 2013).

One way to support residents' wellbeing, and help 'buffer' them against changes to their routines and health conditions, could be through facilitating contact with nature. A high proportion of older adults report that contact with nature is important to them (Finlay, Franke, McKay, & Sims-Gould, 2015; Orr, Wagstaffe, Briscoe, & Garside, 2016; Reynolds, 2016). Moreover, growing evidence indicates that living near to and/or visiting natural environments (e.g. green spaces such as parks, woodland and blue spaces like the coast, lakes and rivers) can have a wide range of health and wellbeing benefits (Gascon et al., 2015; Gascon, Zijlema, Vert, White, & Nieuwenhuijsen, 2017; Mitchell & Popham, 2008; White, Pahl, Wheeler, Depledge, & Fleming, 2017). Though this evidence usually draws on the wider general population; benefits have also been reported in residential care settings. For example, time spent in "nearby nature" - usually the home's garden - has been associated with improved concentration (Ottosson & Grahn, 2005), reduced agitation (Whear et al., 2014), supported feelings of competence (Rappe & Topo, 2007), and increased quality of life (QoL) for residents (Raske, 2010), including for those with dementia (Whear et al., 2014).

Despite these findings, various barriers, such as physical mobility issues, staff shortages and concerns for residents' safety, can make access to nature difficult for long-term care residents (Hernandez, 2007; Kearney & Winterbottom, 2006; Morgan & Stewart, 1999; Reynolds, 2016; Rodiek, 2006). Lack of contact with nature has been associated with chronic stress and poor mental health among the world's increasingly urban populations (McSweeney, Rainham, Johnson, Sherry, & Singleton, 2015). Therefore, it is conceivable that concomitant detachment from nature could exacerbate the potential mental health problems faced by long-term care residents. Finding ways to connect residents with nature might help maintain or improve wellbeing and reduce negative symptoms.

One way to enable nature contact for residents for whom outdoor access is infrequent or impossible, could be to simulate aspects of nature indoors. A 2014 literature review that included adults across the whole lifespan, explored impacts of real and simulated indoor forms of nature, ranging from permanent installations (e.g. building design features, nature art, indoor gardens), to more interim exposures (e.g. photographs and films). Improvements were found in a range of wellbeing outcomes including cognition, physiological stress/restoration, mood/affect, QoL, and reductions in physical pain (McSweeney et al., 2015). Although encouraging, none of the studies in this review focussed on older adults, including those living in long-term care. We anticipated that the circumstances of these individuals, not least their ability to interact with nature autonomously, may be markedly different than the general adult population. Consequently, the current systematic review aimed to fill this evidence gap by synthesising the health impacts of indoor nature exposure for older people in residential settings. Both real and simulated forms of nature were included. The review question was: "is exposure to indoor nature beneficial for the health and wellbeing of older adults in residential settings?"

Research Design and Methods

The review was conducted according to Centre for Reviews and Dissemination (CRD) guidelines (Centre for Reviews and Dissemination, 2009), and the protocol was registered with PROSPERO (CRD42017056750).

Study Eligibility

The PICOS method was used to define eligibility criteria as follows; **P**opulation: Adults aged 60+ (or where the median sample age is 60+) living in any residential setting (including assisted and independent living complexes); **I**ntervention: any form of real or simulated indoor nature exposure (excluding window views of outdoor nature, and animal-assisted therapy); **C**ontrol/comparator: non-nature interventions (e.g. music groups) or no-intervention (i.e. 'usual care') control groups. We also accepted single group before-after-after ('pre/post') studies; **O**utcome: any health or wellbeing outcome; **S**tudy design: any quantitative design. A more thorough description, detailing inclusion and exclusion criteria, is available in Table 1.

Database Search

A Master Search was developed iteratively in the MEDLINE database in consultation with an information specialist. The final list of search terms is available in Appendix 1; terms related to older adults or residential care were combined using the "AND" operator, with terms related to indoor nature interventions. Free-text searching was used together with relevant MeSH subject headings. The Master Search was adapted in twelve databases: CINAHL, AgeLine, Environment Complete, AMED, PsychINFO, EMBASE, HMIC, PsychARTICLES, Global Health, Web of Knowledge, Dissertations and Theses Global, and ASSIA. The search identified 24 papers when it was originally performed in March 2017, and two further papers when it was re-run September 2018.

Grey Literature

OpenGrey, The British Library Catalogue and two global clinical trials registries (clinicaltrials.gov and www.who.int/trialsearch) were searched for grey literature.

Supplementary Search

This included forwards and backwards citation chasing, hand-searching non-indexed journals, searching authors' publication lists, examining key literature reviews (Bossen, 2010; Bringslimark, Hartig, & Patil, 2009; Gonzalez & Kirkevold, 2014; McSweeney et al., 2015; Wang & MacMillan, 2013) and contacting a range of relevant local, national and international organisations.

Screening

All hits were imported into Endnote X7 reference management software and de-duplicated. Title/abstract screening and subsequent full-text screening were performed by two independent reviewers. Where there were disagreements on eligibility, consensus was reached through discussion and, if unresolved, by consulting a third reviewer. A PRISMA flow chart overviewing the searching and screening processes is shown in Figure 1.

Data extraction

Study data were independently extracted by two reviewers using a pre-piloted template (see Appendix 2). Discrepancies arising between reviewers were resolved through discussion and consulting a third reviewer if necessary.

Quality Appraisal

The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (Thomas, Ciliska, Dobbins, & Micucci, 2004) was used by two independent reviewers to appraise study quality. The EPHPP was considered appropriate because it: 1) allows assessment of any quantitative study design, 2) was developed for health promotion interventions, 3) has been judged suitable to be used in systematic reviews of effectiveness, and 4) has adequate construct and content validity (Armijo-Olivo, Stiles, Hagen, Biondo, & Cummings, 2012; Thomas et al., 2004). The tool assesses six domains: (1) selection bias; (2) study design; (3) confounders; (4) blinding; (5) data collection method; and (6) withdrawals/dropouts. Each domain is rated as strong (1 point), moderate (2 points) or weak (3 points) according to EPHPP guidance, and domain scores are averaged to provide a global score. Based on their global score, studies are assigned a quality rating reflecting risk of bias, of weak (2.51-3.00, i.e. high risk of bias), moderate (1.51–2.50, i.e. medium risk of bias) or strong (1.00-1.50, i.e. low risk of bias). We refer to study quality hereafter as ‘strong’, ‘moderate’, or ‘weak’ as a form of shorthand, and to align with the EPHPP language. We did not exclude any studies based on quality.

Data Synthesis

The heterogeneous nature of the study designs and outcome measures precluded meta-analysis and so we provide a narrative synthesis in the results and discussion sections, drawing on study findings (usually reported as difference in group means) with reference to study quality. Most studies did not confirm baseline equivalence, and as such we were unable to accurately calculate post-test effect sizes.

Results

Twenty-six papers were included in the review (see Figure 1).

Overview of studies

Included studies were highly heterogeneous in terms of nature interventions, comparator groups, and health/wellbeing outcomes. An overview of all studies, grouped by intervention, is shown in Table 2, with full study details provided in Appendix 3. Table 2 also indicates the significance of each study outcome, with full results provided Appendix 4, and discussed in the following sections.

Most studies took place after 2000 with the majority published in the last decade (n = 19), although four took place between 1979 and 1998. The studies were conducted in the US (n = 15), Australia (n = 2), Canada (n = 1), Hong Kong (n = 1), Taiwan (n = 1), UK (n = 1), or an unspecified location (n = 5). Settings included nursing homes (n = 9), homes, wings, or units specialised to accommodate people with dementia (n = 6), residential, continuing care, or aged care homes (n = 7), assisted living accommodation (1), and independent living apartment complexes (n = 3).

A total of 930 participants (mean per study: 36; range per study: 10-85) were included in the 26 studies. Across the 18 studies which specified participant ages, mean/median age ranged from 61-89 years. Across the 23 studies which reported participant sex, a mean of 69% were female. Only one study recruited more men than women (Goto, Kamal, Puzio, Kobylarz, & Herrup, 2014).

The interventions, which are detailed more fully below, included indoor gardening and horticulture programmes (which involved active participation by residents), indoor gardens (which residents visited, but were not actively involved in maintaining), indoor plants, nature installations, photographs, films, Virtual Reality, and fish tank aquariums.

Eighteen studies used control or comparison groups (3 randomised controlled trials [RCT], 4 cluster RCT, 8 controlled clinical trials [CCT], and 3 crossover studies) which included usual care, receiving social visits from the researchers or the home's staff, waiting list designs, music groups, and non-nature installations/photographs and films. The remaining eight studies were one-group designs.

A range of functional/physical, physiological, cognitive, behavioural, emotional, and social health and wellbeing outcomes were captured using self-report scales, researcher/carer observations, participant tests and tasks (e.g. for assessing cognition) and direct objective measurements (e.g. for physiological outcomes such as pulse rate). Each study reported between one and seven outcomes.

Study Quality

A summary of the quality appraisal is shown in Table 3. Eighteen of the 26 studies received weak ratings, seven were moderate (Barnicle & Midden, 2003; Edwards, Beck, & Lim, 2014; Lee & Kim, 2008; Martin, 2011; Reynolds, Rodiek, Lininger, & McCulley, 2018; Scott, Masser, & Pachana, 2014; Tse, 2010) and one was strong (D'Andrea, Batavia, & Sasson, 2008). The strongest components across all studies were: 1) study design (i.e. likelihood of bias resulting from allocation processes was minimised, and, where applicable, a method of randomisation was described and justified) and, 2) withdrawals/dropouts (i.e. dropout rates were reported, and a high proportion of participants completed the study), with 62% of studies receiving a 'strong' rating on each of these. The weakest components overall were: 1) confounders (i.e. authors did not indicate whether groups were equivalent at baseline, or did not explain whether/how additional variables were controlled for in the analysis) with 69% receiving a 'weak' rating, and 2) blinding (i.e. authors did not state whether outcome assessors and participants were blind to participant intervention status) with 50% receiving a 'weak' rating.

Interventions

The interventions can be divided broadly into two categories: 1) ‘active’ nature interventions, which involved intentional, direct and tactile interaction with real forms of nature or virtual reality, and 2) ‘passive’ nature interventions, in which participants could observe forms of real nature (e.g. indoor plants, fish aquariums) or simulated nature (e.g. photo walls, nature videos), but were not able to influence or manipulate them.

Active nature studies

Nine out of the ten active nature programmes involved interaction with real forms of nature through ‘indoor gardening’ (Brown, Allen, Dwozan, Mercer, & Warren, 2004; Lee & Kim, 2008; Powell, Felce, Jenkins, & Lunt, 1979; Tse, 2010); ‘horticulture activities’ (Barnicle & Midden, 2003; Collins & O'Callaghan, 2008; Masuya, Ota, & Mashida, 2014); or ‘Horticulture Therapy’ (D'Andrea et al., 2008; Yao & Chen, 2017) programmes. The distinction between these subtypes was unclear; all involved instructor-led activities related to cultivating plants, and most included group discussion. There were generally one or two sessions (totalling 30-120 mins) per week, for 4-10 weeks. Some programmes had specific lessons/plans each week; others were more informal. The other active nature study used a form of Virtual Reality, consisting of a large immersive wall-mounted TV screen depicting a forest scene (Moyle, Jones, Dwan, & Petrovich, 2018). Video game technology allowed participants to interact with and influence the forest elements by moving their hands and arms. Seven of the 10 active nature studies included a control group - most often this was ‘usual care’ (n = 5). Six of the 10 studies were rated as weak quality, three as moderate, and one as strong.

Passive nature studies

These 16 studies used indoor plants (Kiyota, 2009; Webster, 2015), an indoor garden (Goto et al., 2014), nature corridor enhancements (Cohen-Mansfield & Werner, 1998; Martin, 2011; Scott et al., 2014), aquariums (DeSchriver & Riddick, 1990; Edwards & Beck, 2002, 2013; Edwards et al., 2014; Riddick, 1984), or media such as nature photos or videos (Aslakson, 2010; Chung, Choi, & Kim, 2014; Eggert et al., 2015; Kieffer, 2014; Reynolds et al., 2018). The duration of the interventions ranged from a 25-minute photo viewing session (Kieffer, 2014), up to a 6 month longitudinal study involving an aquarium intervention (Riddick, 1984), but most interventions ran for 2-8 weeks. Sample sizes tended to be smaller in the passive (mean n = 33, range 11-71) than the active (mean n = 41, range 10-85) nature studies, and quality was marginally lower, with 12/16 studies being weak, and four being moderate. Eleven studies included control groups, but other designs were less robust, including one cross-sectional study (Kieffer, 2014). A greater proportion of the passive nature studies (11/16), compared to active nature studies (3/10), specifically recruited people with dementia, who lived in specialised dementia units, memory care units, or nursing homes. The remaining five passive nature studies all took place in independent living facilities.

Outcomes

The results of each study are indicated in Table 2, detailed fully in Appendix 4, and discussed in the sections below.

Dementia-related outcomes

Twelve studies measured impacts of indoor nature on dementia-related outcomes such as cognition and agitation. Effects were inconsistent, with nature interventions often proving no more effective than comparators such as music therapy (Aslakson, 2010), ‘home-like’ corridor installations (Cohen-Mansfield & Werner, 1998; Martin, 2011) or a generational movie (Reynolds et al., 2018). Agitation and cognitive decline were significantly lower in higher quality gardening studies (D'Andrea et al., 2008; Lee & Kim, 2008), but not in a lower quality horticulture study (Masuya et al., 2014). Other dementia-related behaviours were more often targeted using passive interventions in weaker quality studies (Cohen-Mansfield & Werner, 1998; Goto et al., 2014; Webster, 2015), and results and reporting standards were mixed.

Psychological wellbeing outcomes

Twelve studies measured impacts on psychological wellbeing, with outcomes ranging from emotional states such as mood and affect, to clinically-relevant indicators of anxiety and depression. Reporting tended to be better and sample sizes larger for psychological wellbeing than dementia-related outcomes. Nevertheless 8/12 studies received weak ratings despite six of these including control groups.

Weak ratings were usually due to problems with researcher-participant blinding (an understandable challenge in a care home setting), and/or failure to account for potential confounders.

Active interventions were associated with significant improvements across weak (Masuya et al., 2014; Moyle et al., 2018; Yao & Chen, 2017) and moderate (Barnicle & Midden, 2003; Tse, 2010) studies measuring depression (Masuya et al., 2014), happiness (Yao & Chen, 2017), affect (Barnicle & Midden, 2003), and loneliness (Tse, 2010). Significant improvements occurred more frequently where the control group was 'usual care'. By contrast, comparator groups, e.g. receiving social visits (Brown et al., 2004), were just as effective as active nature-based interventions, for psychological wellbeing. Other studies found improvements in apathy during exposure to a Virtual Reality forest (Moyle et al., 2018), and in happiness and mastery following a horticulture activity programme (Collins & O'Callaghan, 2008), but both were based on small samples and lacked control groups.

Effects of passive interventions were inconsistent, but generally more effective for interim outcomes such as pleasure (Cohen-Mansfield & Werner, 1998; Reynolds et al., 2018), and perceived restoration (Kiyota, 2009), than clinical ones like anxiety or depression (Kiyota, 2009; Reynolds et al., 2018; Scott et al., 2014), which may reflect that the interventions had relatively short time frames. Happiness scores improved for participants who received a home aquarium plus researcher visits, relative to a visits-only group, or no-intervention controls (Riddick, 1984), but as between-groups inferential analyses were not conducted; the statistical significance of these effects was unclear.

Social outcomes

Social engagement and interpersonal intimacy significantly improved in weak (Yao & Chen, 2017) and moderate (Tse, 2010) studies that compared gardening/horticulture programmes against ‘usual care’. However, there were no significant improvements over alternative types of interventions including 20-minute social visits (Brown et al., 2004) or a ‘reminiscence’ installation (Scott et al., 2014) in weak- and moderate-quality studies respectively.

Functional and physical outcomes

Seven studies measured functional or physical health and wellbeing, in terms of Activities of Daily Living (ADL) (Brown et al., 2004; Masuya et al., 2014; Tse, 2010; Yao & Chen, 2017), sleep (Lee & Kim, 2008), and nutritional intake and body weight (Edwards & Beck, 2002, 2013). Of one moderate (Tse, 2010) and three weak (Brown et al., 2004; Masuya et al., 2014; Yao & Chen, 2017) studies that measured ADL before and after completion of controlled indoor gardening/horticulture programmes lasting 5-8 weeks, only one weak-quality study found significant positive effects (Yao & Chen, 2017). There were indications that indoor gardening and fish aquariums were able to improve the quality and quantity of sleep (Lee & Kim, 2008) and nutritional intake/body weight (Edwards & Beck, 2013) respectively, for people with dementia, but these studies lacked control groups for comparison.

Physiological outcomes

One moderate-quality and three weak-quality studies investigated whether passive nature interventions (a nature film (Reynolds et al., 2018), fish aquariums (DeSchriver & Riddick, 1990; Riddick, 1984), or an indoor garden (Goto et al., 2014)) could alter indicators of physiological stress, such as pulse rate and blood pressure.

A moderate-quality crossover study reported that average heart rate significantly decreased for people with dementia when they watched a nature film, but not when they watched a generational movie (Reynolds et al., 2018). Although the other studies also used controlled designs; all suffered from poor reporting, with no between-group comparisons made in two (Goto et al., 2014; Riddick, 1984) and mismatches between tabulated data and study conclusions in the other (DeSchriver & Riddick, 1990).

General health, wellbeing, and satisfaction

The remaining outcomes comprised various measures of satisfaction (Riddick, 1984; Scott et al., 2014; Tse, 2010), engagement (Aslakson, 2010; Eggert et al., 2015; Moyle et al., 2018; Powell et al., 1979), and self-perceived health, wellbeing, and QoL (Collins & O'Callaghan, 2008; Kieffer, 2014; Masuya et al., 2014; Yao & Chen, 2017). At least some significant improvements were reported in all five studies which employed gardening/horticulture programmes (Collins & O'Callaghan, 2008; Masuya et al., 2014; Powell et al., 1979; Tse, 2010; Yao & Chen, 2017). Increases in engagement occurred only with gardening (Powell et al., 1979), and not with photos (Eggert et al., 2015) or videos (Aslakson, 2010). None of the studies using passive nature reported any positive effects. In fact, the reverse was true in a moderate-quality RCT of a biophilia installation, where outcomes instead favoured the ‘reminiscence’ installation and no-installation comparator groups (Scott et al., 2014).

Discussion and Implications

Key Findings

This systematic review aimed to evaluate the evidence that indoor nature interventions might improve the health and wellbeing of older adults in residential settings. On the whole, there was little robust evidence of improvements with most studies receiving a weak quality rating, indicating a high risk of potential bias (18/26) using the EPHPP criteria.

Nevertheless, interventions involving physical interaction with real forms of nature, such as indoor gardening programmes, appeared to be more effective than passive interventions such as nature installations or photographs. The strongest study (i.e. with low risk of bias) reported significantly less cognitive decline for people with Alzheimer's Disease, following a Horticulture Therapy programme (D'Andrea et al., 2008). In addition, two controlled gardening studies, both of moderate quality, reported improvements in affect balance (Collins & O'Callaghan, 2008), and loneliness, social engagement and life satisfaction (Tse, 2010). Of the seven gardening/horticulture studies that included control/comparator groups, six reported significant between-group differences favouring nature in at least one measured health/wellbeing outcome (Barnicle & Midden, 2003; D'Andrea et al., 2008; Masuya et al., 2014; Powell et al., 1979; Tse, 2010; Yao & Chen, 2017). This was the case for only four (Goto et al., 2014; Kiyota, 2009; Reynolds et al., 2018; Scott et al., 2014) of the 11 controlled passive nature studies. These findings align with seminal works which describe incremental wellbeing benefits with increasing nature engagement, from 'indirect' (i.e. passive viewing), up to 'intentional' (i.e. active) participation in nature (Keniger, Gaston, Irvine, & Fuller, 2013; Pretty, 2004).

In terms of outcomes, significant positive effects were reported for psychological and social wellbeing, engagement, life satisfaction, and QoL indicators across several controlled studies of both weak (Kiyota, 2009; Masuya et al., 2014; Powell et al., 1979; Yao & Chen, 2017) and moderate (Barnicle & Midden, 2003; Reynolds et al., 2018; Scott et al., 2014; Tse, 2010) quality. This reflects a growing evidence base arguing that contact with nature can: 1) support mental health/wellbeing (Bragg & Atkins, 2016); and, 2) bring people together, increasing social capital/cohesion, reducing loneliness, and creating a sense of community (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Maas, van Dillen, Verheij, & Groenewegen, 2009). Effects on functional/physical, physiological, and dementia-related outcomes were more mixed, with some positive effects of gardening and horticulture programmes (D'Andrea et al., 2008; Yao & Chen, 2017), fish aquariums (Edwards & Beck, 2002; Riddick, 1984), nature films (Reynolds et al., 2018), and Virtual Reality (Moyle et al., 2018).

Effects of interventions for people with dementia

More than half of the studies (14/26) specifically stated recruitment of individuals with dementia, but only eight of these included control groups. Of these, four studies reported significant improvements in outcomes ranging from cognition (D'Andrea et al., 2008) and heart rate (Reynolds et al., 2018) in strong and moderate studies, to behavior (Goto et al., 2014) and nutritional intake (Edwards & Beck, 2002) in weaker studies. On the whole, these interventions were structured activities that specifically required participants to attend, and all involved the researcher or staff staying in the room with the participants during their nature exposure. Most aimed to engage residents frequently, with the majority being accessible either every day (Edwards & Beck, 2002) or twice per week (D'Andrea et al., 2008; Goto et al., 2014). The diversity of the successful interventions, spanning Horticulture Therapy, an indoor garden, a fish aquarium and an Immersive Virtual Nature experience, suggest that a variety of active and passive indoor nature mechanisms may be beneficial in supporting the health of older adults with dementia. However, further, high-quality research is needed to substantiate this given the small number of robust studies.

Links with theory

Most studies identified a theoretical basis for their research but this was usually limited to paper introductions and rarely elaborated in their discussions. The most frequently referenced theories concerned wellbeing impacts of nature rooted in evolutionary psychology. For example, four studies (Edwards & Beck, 2013; Martin, 2011; Scott et al., 2014; Webster, 2015) mentioned the Biophilia Hypothesis, which posits that because humans evolved in nature, we retain an innate connection with living things (Wilson, 1984). Ten studies made direct or indirect reference to one or both of two classic theories which argue that the content and structure of natural settings can promote psychologically restorative experiences, allowing for recovery of attentional processes (Attention Restoration Theory (Kaplan & Kaplan, 1989)) and/or recovery from psycho-physiological stress (Psychological Stress Reduction Theory (Ulrich, 1981)). However, only half of these studies included outcomes directly relating to attention (Chung et al., 2014; D'Andrea et al., 2008), stress (Reynolds et al., 2018), or restoration (Kiyota, 2009; Webster, 2015).

Others specified broader environmental theories, proposing that wellbeing of people with dementia improves when care homes’ physical environments are altered in order to provide enrichment (Edwards et al., 2014), reduce vulnerability (Aslakson, 2010) and reduce inappropriate stimulation (Cohen-Mansfield & Werner, 1998). However, these studies did not necessarily stipulate a special or unique role for nature in these processes. Others worked within wider theoretical contexts, including health promotion (Brown et al., 2004), physical activity (Lee & Kim, 2008), and Theory of Personhood (Masuya et al., 2014), and here nature seemed to be coincidental to the intervention's goal, rather than its central focus.

Hence, though many studies did identify a theoretical basis, few explicitly linked theory with outcomes or worked within a specified theoretical framework. Moreover there was little attempt to work across/integrate different theories, or to develop conceptual models of anticipated mechanisms/pathways/contextual factors linking nature-based interventions to wellbeing outcomes, in care settings. Future work in this area would benefit from a Complex Interventions-based approach (Craig et al., 2008) that attempts to unpick which kinds of interventions generate the most beneficial impacts, for which outcomes, for whom, and in what circumstances.

Identifying key features of stronger interventions

We analysed the eighteen controlled studies from several perspectives (e.g. sample size, intervention duration/frequency, setting, dementia diagnosis, data collection procedure) to try and identify factors that may moderate or mediate effective indoor nature interventions. Though the majority of results were inconsistent, we found that larger proportions of the studies lasting more than 5 weeks (7/9), and those set in nursing homes (7/10), reported significant findings, compared with those lasting 5 weeks or less (3/9), or based in other settings (3/8). A smaller proportion of the studies specifically recruiting people with dementia reported any significant results (4/8), compared with those recruiting more widely (7/10). The proportions of findings which were statistically significant were similar regardless of whether the staff/researcher (37.5%) or resident themselves (40%) completed the outcome measure.

By cross-referencing Tables 1-3, we identified features which tended to persist across studies reporting significant positive effects. We observed that, regardless of whether or not they involved gardening/horticulture activities, interventions were more likely to be effective when they afforded: 1) shared/group experiences; 2) acquiring knowledge and learning skills; and/or, 3) opportunities to have control/autonomy, provide care, or be responsible for nature. Each of these factors: social interaction (Bassuk, 1999; Graney, 1975; Mendes de Leon, Glass, & Berkman, 2003), lifelong learning (Narushima, Liu, & Diestelkamp, 2013, 2018), and having responsibility/autonomy (Kloos, Trompetter, Bohlmeijer, & Westerhof, 2018; Langer & Rodin, 1976), have been reported to benefit older adults' wellbeing, in terms of ADL (Mendes de Leon et al., 2003), happiness (Graney, 1975), cognition (Bassuk, 1999), depression (Kloos et al., 2018), general psychological wellbeing (Kloos et al., 2018; Narushima et al., 2013), general overall health (Langer & Rodin, 1976), and life satisfaction (Kloos et al., 2018), i.e. similar outcomes to those reported in this review. Horticulture Therapy is similarly modelled as providing a diverse range of emotional, physical, intellectual and social mechanisms (Relf, 2006); we expect therefore, that the gardening and horticulture programmes in particular was due in part to provision of these experiences, rather than through fostering interaction with nature *per se*.

Strengths of the Systematic Review process

As far as we are aware, this is the first systematic review to evaluate the evidence of indoor nature interventions on the health and wellbeing of older adults in residential settings. Our search strategy used an extensive keyword list, represented diverse disciplines, and included unpublished literature. Despite being unable to perform meta-analyses, we attempted to assimilate studies through narrative and tabulation. Finally, we only included studies which took place in residential environments, allowing a degree of confidence in the external validity of the findings.

Strengths of the included studies

Through the quality appraisal process, we found that participants did not tend to withdraw from ‘opt-in’ interventions. This was particularly the case with gardening programmes, for which six of nine programmes reported 100% completion rates, indicating that they appear to be largely acceptable/enjoyable. In addition, most studies included a control group(s), and outcome measures often had clinically meaningful thresholds or interpretations. Many studies avoided an ethical dilemma by ensuring that no residents ‘missed out’ on the experiencing the intervention (e.g. by employing waiting list or crossover designs), and this inclusivity was noted to make the studies more acceptable to carers and residents’ families. Finally, some papers noted that care staff also benefited from the interventions. Although further investigation was not within the scope of this review, wellbeing impacts of outdoor nature for residential care staff have been discussed as part of a previous review (Whear et al., 2014).

Limitations of the review process

We recognise some key limitations of the review process. First, we opted to use the EPHPP because it was the only validated, reliable quality appraisal tool that could be used with a wide range of quantitative studies, but we also recognise some issues in its use. For example, the EPHPP tool's scoring instructions are unbalanced, so that a study receiving two weak and four strong subcategory scores receives the same weak overall global score, as another study receiving six weak subcategory scores. Furthermore global scores are based on a non-weighted summation of the subcategories, which overlooks that some risks may be more important than others. Second, by only including quantitative studies, the review perhaps lacked an in-depth exploration of the relationships between interventions and outcomes that may have been afforded by including qualitative data. We may also have missed some studies by including only English language papers.

Limitations of the included studies

Several issues affected the majority of studies, including: 1) small sample sizes, which conceivably meant most studies were under-powered to detect significant between-group effects; 2) lack of random allocation procedures, or else failure to account for basic demographic factors (age, sex) in the analyses, either of which risks introducing confounding; and, 3) a lack of researcher-participant blinding. In addition, a smaller number of studies did not report between-groups analyses for some (Goto et al., 2014) or any (Brown et al., 2004; Cohen-Mansfield & Werner, 1998; Edwards & Beck, 2002; Eggert et al., 2015; Riddick, 1984) of their outcomes, meaning the relative effects of their nature intervention arm(s) could not be evaluated. Furthermore, as most studies did not confirm baseline equivalency; we could not accurately calculate the magnitude of their effects.

In addition, these kinds of field intervention studies are naturally susceptible to uncontrollable biases. For example, selection effects might have been introduced if residents opting take part in gardening were particularly 'green-fingered' (and thus not necessarily representative of the general care population). Observer-expectancy effects are also possible, e.g. if some residents felt the need to please the researchers in order to maintain social interaction with them (i.e. social desirability bias). The latter is particularly pertinent in this review considering 1) widespread positive impacts on social wellbeing were observed, and 2) social interaction is often limited in these settings.

Though the above issues reduced our confidence in the findings, we accept that researchers in this field often face multiple challenges with recruiting large samples and that avoiding experimenter effects is near-impossible. We understand also, that there may be ethical concerns in including control groups, which effectively deny half of a care home sample access to an intervention which may benefit them. However, one area we feel could be improved is data reporting - as basic demographic information, summary statistics, and/or study means/medians were sometimes missing (Aslakson, 2010; Brown et al., 2004; Chung et al., 2014; Edwards & Beck, 2002; Goto et al., 2014; Moyle et al., 2018; Powell et al., 1979). In addition very few papers stated the proportion of their sample who were living with dementia or health conditions, which may have important implications for recruitment, retention and outcome effects.

Conclusions

The impact of indoor nature on older residents' wellbeing is currently unclear. Though several higher-quality studies indicated improvements in dementia-related, social, and psychological wellbeing outcomes; the vast majority of studies were of weak quality, which made it difficult to present a comprehensive overview. Nevertheless, there is some suggestion that active involvement, e.g. through indoor gardening programmes, has greater potential to provide benefits than more passive exposures such as nature corridor installations. Mechanisms underlying these interactions may include provision of opportunities for social stimulation, development of skills, and/or having responsibility to care for nature, but further research is needed to fully elucidate these associations.

Recommendations for practice and future research

Despite the mixed findings of this systematic review, the gardening and horticulture programmes were, on the whole, more effective than passive forms of nature. The current evidence does not allow us to recommend indoor nature interventions over other types of intervention or activities. However, in the event that practitioners are looking to utilise indoor forms of nature, we tentatively suggest facilitation of direct and active nature contact may be more effective for wellbeing, than more passive forms. In addition, interventions seem more likely to benefit residents' health and wellbeing where there is co-provision of opportunities for social stimulation, skills development, decision-making, and/or the chance to take responsibility or care for nature.

This review identified several research gaps for consideration. First, most studies only measured outcomes before-and-after; it would be valuable to conduct longitudinal studies which collect data throughout or following the intervention, to allow for interrogation of some of the more implicit, purported nature-wellbeing mechanisms - e.g. do the social interactions noted in this review develop into lasting friendships? Second, we suggest that future research works within the Complex Interventions framework to elucidate more clearly the mechanisms and pathways involved in generating wellbeing impacts from nature-based interventions in care settings. Third, we would like to see co-creation of nature-based interventions alongside the residents, to determine whether this increases beneficial wellbeing effects. Finally, though most of the passive nature conditions in this review produced few effects, it is conceivable that their lower cost, maintenance, time, and space requirements mean they are more routinely implemented than active interventions. It would be interesting to see whether emerging technologies, such as low-cost mobile head-mounted Virtual Reality, are able to produce a 'compromise', by combining together the interactive elements of active interventions, with the scenic quality and modifiability of passive interventions, to provide highly immersive indoor nature experiences.

Conflict of Interest

We have no conflict of interest to declare

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Tables

Table 1. Study eligibility criteria

	Population	Intervention	Comparator/ Control	Outcomes	Study design	Setting
Inclusion criteria	• Adults aged 60+ (or where the median age was 60+, or the majority of participants were aged 60+)	• Exposure to any form of indoor real, artificial or virtual/ simulated nature including but not limited to: indoor gardening/ horticulture programmes, indoor gardens/plants, nature art/imagery, videos, and virtual reality.	• Non-nature interventions (e.g. music groups, receiving visitors) • No-intervention controls (i.e. 'usual care') • Non-controlled studies	• Any health or wellbeing outcome(s). • Health was based on the WHO definition, encompassing physical psychological and social aspects. • Wellbeing was considered as more holistic, encompassing functional and behavioural aspects, feelings, emotions and moods.	• Any quantitative design. • Mixed methods were accepted if the quantitative aspect could be separated.	• Residential settings: defined as anywhere participants were currently living and primarily considered 'residents', i.e. not 'patients', 'inmates' or 'workers'
Exclusion criteria	• Average age across sample was under 60	• Nature exposure wholly or partially experienced outdoors • Window views, e.g. onto		• Health and/or wellbeing outcomes were not reported	• There was no quantitative data • Quantitative data could not be	• Anywhere where the ultimate aim was discharge from the facility, such as hospitals

		countryside and gardens • Studies where it was not possible to distinguish the impact of nature from other aspects of multi-component interventions • Studies on pet or animal-assisted therapy • Studies about impact of sunlight or UV exposure		separated from qualitative data in mixed methods studies.	and rehabilitation centres. • Prisons • Vacation or respite settings • Work-based settings
Additional requirements	• Written in English. • Presented within academic journals, dissertations or theses, • The full-text of the article had to be available/retrievable where abstracts alone did not provide sufficient information to apply quality appraisal criteria • There were no restrictions according to publication status or dates				

Table 2. Individual study information and outcomes

First author, year, country	Study design (quality score)	Sample	Residence type	Intervention(s)	Comparator(s) /control(s)	Frequency/ duration	Outcome(s)	W[a]	B[b]
Indoor gardening and horticulture programmes									
D'Andrea, 2008, USA	RCT (Strong)	40 (AZD)	Nursing home	Horticulture therapy programme	Various regular scheduled activities e.g. music sessions, reminiscence discussions, socialising	2x 30-45 min sessions per week for 12 weeks	1. Cognition	-	✓
Brown, 2004, USA	Cluster RCT (Weak)	66	Nursing home	Indoor gardening programme	20 minute visits from care staff	1x session[c] per week for 5 weeks	1. ADL		
							2. Socialisation	-	-
							3. Loneliness	-	-
Tse, 2010, Hong Kong	Cluster RCT (Moderate)	53	Nursing home	Indoor gardening programme	Usual care	1 x session[c] per week for 8 weeks	1. ADL	-	-
							2. Socialisation	✓	✓
							3. Loneliness	✓	✓
							4. Life Satisfaction	✓	✓
Powell, 1979, UK	CCT (Weak)	32 (physically frail)	Residential home	Gardening days	Non-gardening days (usual care)	1x session[c] per week for 10 weeks	1. Engagement		✓
Barnicle & Midden, 2003, USA	CCT (Moderate)	62	Residential home	Horticulture activity programme	Usual care (waiting list)	1x 1h session per week for 7 weeks	1. Affect	-	✓
		18			Usual care		1. Cognition		

Masuya, 2014, not specified	CCT (Weak)		Nursing home	Horticultural activity programme		1x 30-40 min session per week for 6 weeks	2. Depression	✓	✓
							3. ADL	-	-
							4. QoL	-	-
Yao, 2017, Taiwan	CCT (Weak)	85	Nursing home	Horticulture therapy programme	Usual care (waiting list)	1x 1h session per week for 8 weeks	1. ADL	✓	✓
							2. Happiness	✓	✓
							3. Meaning of life	-	-
							4. Interpersonal intimacy	✓	✓
Collins, 2008, USA	One-group pre/post (Weak)	18	Assisted living facility	Horticulture activity programme	N/A	1x 2h session per week for 4 weeks	1. Mastery	✓	
							2. SR health	✓	
							3. SR happiness	✓	
Lee, 2008, not specified	One-group pre/post (Moderate)	23 (mild to severe dementia)	'Institution'	Indoor gardening programme	N/A	2x 1h sessions per day, every day for 28 days; participants could also access their plants whenever they wanted	1. Agitation	✓	
							2. Cognition	✓	
							3. Sleep	✓	
Indoor gardens and plants									
Kiyota, 2009, Canada	Three-group cluster RCT (Weak)	30	Small houses within elderly care complex	1) Indoor plants: active group 2) Indoor plants:	No plants	Plants placed in the living room for 6 weeks.	1. Perceived restoration	-	✓
							2. Depression	-	-

				passive group		Cared for by participants (active) or staff (passive)			
Goto, 2014, USA	CCT (Weak)	36 (late stage dementia)	Nursing home	Indoor Japanese garden	1) Snoezelen room 2) control space (participant's bedroom)	2 x 15 min sessions per week for 3 weeks (Snoezelen) or 4 weeks (garden)	1. Physiological stress (pulse rate)		
							2. Behaviour		✓
Webster, 2015, USA	One-group ABABB (Weak)	11 (dementia)	Memory care wing of continuing care facility	Indoor plants	N/A	Plants installed on day 1, removed on day 6, replaced on day 8 and finally removed on day 15	1. Cognition		
							2. Behaviour		
Indoor nature installations									
Scott, 2014, Australia	Three-group cluster RCT (Moderate)	33	Residential aged care facility	Biophilia installation	1) Reminiscence installation 2) No installation	4 weeks	1. Anxiety	-	-
							2. Depression	-	-
							3. Social engagement	✓	✓
							4. Satisfaction with living environment	-	-
							5. Satisfaction with opportunities for keeping occupied	-	-

Martin, 2011, USA	Cluster-randomised crossover (Moderate)	22 (AZD)	Nursing home	Nature slide show looped corridor projection (180 photos)	Nursing home interiors slide show looped corridor projection (180 photos)	Projections looped for 5 days between 09:00 and 17:00	1. Agitation	-	-
Cohen-Mansfield, 1998, not specified	Quasi-crossover (Weak)	27 (residents who pace frequently; 92.6% had dementia)	Nursing home	Nature corridor enhancement	'Home' corridor enhancement	4 weeks each	1. Agitation	-	-
							2. Dementia-related behaviours	-	-
							3. Mood	-	-
Nature photographs, films and immersive virtual nature experiences									
Aslakson, 2010, USA	RCT (Weak)	40 (dementia)	Nursing home	Nature videos	Music therapy	3 x 30-40 min sessions over 1 week	1. Agitation	-	-
							2. Engagement	x	x
							3. Functional behaviour	-	-
Eggert, 2015, not specified	Two group pre/post (Weak)	13 (dementia)	Memory care unit of assisted living facility	Preferred nature images (photographs)	Preferred music	1x 90 min session per week for 4 weeks	1. Cognition		
							2. Engagement		
							3. Agitation		
Reynolds, 2018, not specified	Quasi-Crossover (Moderate)	14 (mild to severe dementia)	Memory unit of assisted living facility	Immersive nature experience, including film on 65-inch TV, plus artificial plants and nature photos	Generational movie on 65-inch TV	3 x trials involving 10 min exposure to each condition. 1 day washout between conditions and 1 week between trials.	1. Observed emotions	-	-
							2. Agitation	-	-
							3. Heart rate	✓	✓

Moyle, 2018, Australia	One-group pre/post (Weak)	10 (dementia)	Residential aged care facility	Virtual Reality Forest (Large interactive wall-mounted 2D screen)	NA	1x session of 8-12 min duration.	1. Observed emotions		
							2. Apathy	✓	
							3. Engagement		
Chung, 2016, USA	One-group pre/post (Weak)	23 (dementia)	Nursing home	Nature media presentations (DVDs)	N/A	1x 7-10 min session, 3x per week for 2-4 weeks	1. Agitation	-	
Kieffer, 2014, USA	Cross-sectional (Weak)	20	Private senior independent living community	Representational elements of nature (photographs)	N/A	1x 25 min interview	1. Perceived wellbeing		
Aquariums									
DeSchriver, 1990, USA	RCT (Weak)	27	Publicly-subsidised housing unit	Fish aquarium	1) Fish videos[d] 2) Videos of static	1 x 8 min session per week for 3 weeks	1. Cardio-vascular activity (proxy for physiological stress)	-	-
Edwards, 2002, USA	CCT (Weak)	62 (AZD)	Dementia-specific unit	Fish aquarium	Scenic ocean picture[d] (waiting list)	Aquarium for 8 weeks; scenic ocean picture for 2 weeks. Both visible at mealtimes	1. Nutritional Intake	✓	
							2. Body weight		
Riddick, 1985, USA	Three-groups CCT (Weak)	24	Publicly-subsidised apartments	Fish aquarium plus researcher visits	1) Researcher visits only 2) Control (no aquarium, no researcher visits)	10 x 20-40 min visits once per fortnight	1. Diastolic blood pressure	✓	
							2. Systolic blood pressure	-	
							3. Happiness	-	

							4. Anxiety	-
							5. Loneliness	-
							6. Leisure satisfaction	-
Edwards, 2013, USA	One-group pre/post (Weak)	70 (dementia)	Specialised dementia unit	Fish aquarium	N/A	8 weeks, visible at mealtimes	1. Food Intake	✓
							2. Body weight	✓
Edwards, 2014, USA	One-group pre/post (Moderate)	71 (dementia)	Specialised dementia unit	Fish aquarium	N/A	8 weeks, visible at mealtimes	1. Behaviour	✓

Table 3. Quality appraisal/Risk of bias

Lead Author	EPHPP subcategory: Selection bias	Study design	Confounders	Blinding	Data collection method	Withdrawals and dropouts	Global rating
Aslakson	M	S	S	S	W	W	**Weak**
Barnicle	M	S	S	W	S	S	**Moderate**
Brown	M	S	S	W	S	W	**Weak**
Chung	M	M	W	W	W	S	**Weak**
Cohen-Mansfield	M	S	W	M	W	W	**Weak**
Collins	M	M	W	W	S	S	**Weak**
D'Andrea	M	S	M	M	S	S	**Strong**
DeSchriver	W	S	W	W	S	S	**Weak**
Edwards (2002)	M	S	W	M	W	S	**Weak**
Edwards (2013)	M	M	W	M	W	S	**Weak**
Edwards (2014)	M	M	W	M	S	S	**Moderate**
Eggert	W	M	W	M	S	M	**Weak**
Goto	M	S	W	M	W	W	**Weak**
Kieffer	M	W	W	W	W	W	**Weak**
Kiyota	W	S	W	M	S	S	**Weak**
Lee	M	M	W	M	M	S	**Moderate**
Martin	M	S	S	W	S	S	**Moderate**
Masuya	M	S	W	W	S	S	**Weak**
Moyle	M	M	W	W	S	W	**Weak**
Powell	M	S	W	M	W	W	**Weak**
Reynolds	M	W	S	M	S	M	**Moderate**
Riddick	W	S	W	W	S	S	**Weak**
Scott	M	S	S	M	W	M	**Moderate**
Tse	M	S	S	W	S	S	**Moderate**
Webster	M	M	W	W	W	S	**Weak**
Yao	M	S	W	W	S	S	**Weak**

Figures

Figure 1. Study selection flowchart

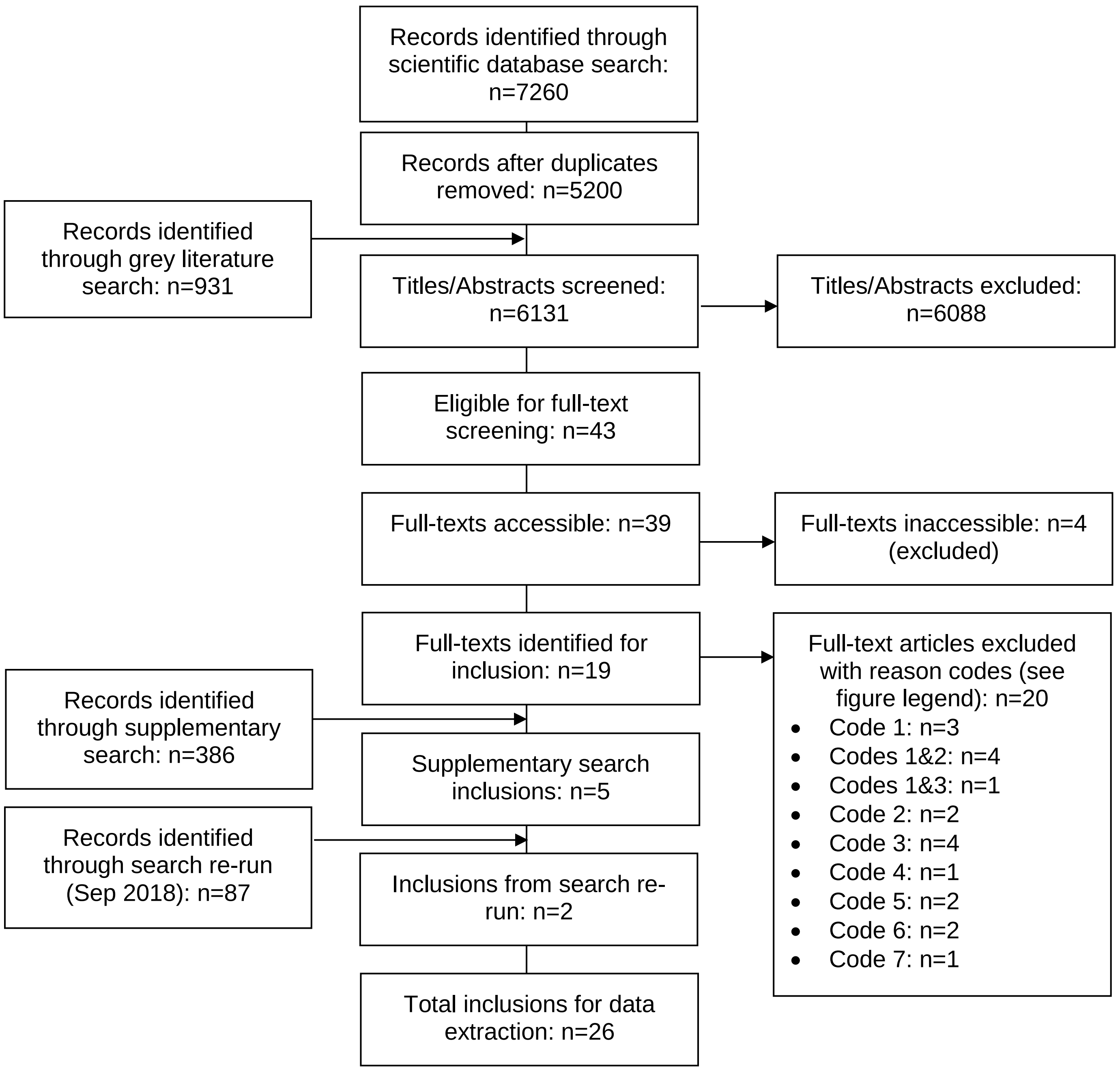

Table and Figure legends

Table 1. Study eligibility criteria. Studies were required to meet all of the inclusion and exclusion criteria, and several additional requirements, to be eligible for inclusion in the systematic review.

Table 2. Overview of individual studies. AZD Alzheimer's disease; CCT controlled clinical trial; N/A not applicable; QoL Quality of Life; RCT randomised controlled trial; SR self-reported; [a]green within-group changes; [b]between-group changes; [c]duration of sessions not indicated; [d] condition was a control group in the individual study but is considered as an intervention for the current review. In the W column, green (✓) indicates the intervention group (but not the control/comparator group, if included) was significantly effective over time; yellow (-) indicates the intervention group had no significant effect over time; red (X) indicates the control/comparator group (but not the intervention group) was significantly effective over time. In B column, green (✓) indicates a significant difference favouring intervention; yellow (-) indicates no between-group differences; red (X) indicates a significant difference favouring control/comparator. In either W or B column, no colour/symbol means results were inconsistent/mixed, direction of effect(s) were unclear, some results were not reported, the study only reported descriptive statistics, or the test was not performed or not applicable.

Table 3. Quality appraisal was performed according to EPHPP criteria. The subcategories were scored as being weak (W), moderate (M) or strong (S). The subcategories were then averaged to calculate the global rating.

Figure 1. PRISMA flow diagram outlining study selection process. Exclusion codes: 1) study set in an environment where the participants were not living permanently; 2) the majority of participants were aged under 60; 3) nature exposure was wholly or partially experienced outdoors; 4) study did not use quantitative data; 9) not enough detail was available to apply the quality appraisal criteria; 6) study duplicates material from an already-included study; 7) no nature intervention included.

Supplementary items

Appendix 1. Database Search Terms

Line	Term
1	elder*.ti,ab.
2	older.ti,ab.
3	aged.ti,ab
4	aging.ti,ab.
5	ageing.ti,ab.
6	geriatric.ti,ab.
7	senior.ti,ab.
8	retire*.ti,ab.
9	veteran.ti,ab.
10	pensioner*.ti,ab.
11	"old age*".ti,ab.
12	"over 60*".ti,ab.
13	"over 65*".ti,ab.
14	sixties.ti,ab.
15	“over 70”.ti,ab.
16	seventies.ti.ab.
17	"over 80".ti,ab.
18	eighties.ti,ab.
19	"care home*".ti,ab

20	“care facilit*”.ti,ab.
21	"nursing home*".ti,ab.
22	"residential home*".ti,ab.
23	"residential facilit*".ti,ab.
24	institution*.ti.ab.
25	"community care".ti,ab.
26	"assisted living".ti,ab.
27	"green house project".ti,ab.
28	"sheltered housing".ti,ab.
29	dement*.ti,ab.
30	Alzheimer*.ti,ab.
31	Aged/
32	Aging/
33	Aged 80 and over/
34	Frail Elderly/
35	Middle Aged/
36	Homebound Persons/
37	Veterans/
38	Geriatrics/
39	Retirement/

40	Alzheimer Disease/
41	Dementia/
42	Assisted Living Facilities/
43	Homes for the Aged/
44	Housing for the Elderly/
45	Group Homes/
46	Senior Centers/
47	Long-Term Care/
48	Institutionalization/
49	Nursing Homes/
50	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49
51	(indoor* adj2 garden*).ti,ab.
52	(interior* adj2 garden*).ti,ab.
53	(internal adj2 garden*).ti,ab.
54	(garden* adj2 room).ti,ab.
55	"enclosed garden*".ti,ab.
56	(indoor* adj2 horticultur*).ti,ab.
57	(interior adj2 horticultur*).ti,ab.
58	(internal adj2 horticultur*).ti,ab.

59	(indoor* adj2 plant*).ti,ab.
60	(interior adj2 plant*).ti,ab.
61	houseplant*.ti,ab.
62	“house plant*”.ti,ab.
63	"potted plant*".ti,ab.
64	aquari*.ti,ab.
65	"fish tank*".ti,ab.
66	(natur* adj2 indoor*).ti,ab.
67	(natur* adj2 inside).ti,ab.
68	(natur* adj2 home*).ti,ab.
69	(natur* adj2 image*).ti,ab.
70	(natur* adj2 scene*).ti,ab.
71	(natur* adj2 pictur*).ti,ab.
72	(natur* adj2 photo*).ti,ab.
73	(natur* adj2 art*).ti,ab.
74	(natur* adj2 mural*).ti,ab.
75	(natur* adj2 depict*).ti,ab.
76	(natur* adj2 represent*).ti,ab.
77	(natur* adj2 paint*).ti,ab.
78	(natur* adj2 film*).ti,ab.
79	(natur* adj2 movie*).ti,ab.
80	(natur* adj2 video*).ti,ab.

81	(natur* adj2 recording*).ti,ab.
82	(natur* adj2 sound*).ti,ab.
83	(natur* adj2 audio*).ti,ab.
84	(natur* adj2 virtual*).ti.ab
85	(natur* adj2 simulat*).ti.ab
86	(natur* adj2 artificial*).ti.ab
87	51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86
88	50 and 87

The search was made in the MEDLINE database via Ovid host, with Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R) selected. Each search line was submitted independently into the basic search field, with title and abstract fields selected (except for MeSH terms, which used a /, as shown in steps 31-49). The search lines relating to older adults/residential settings and indoor nature were combined with OR at steps 50 and 87 respectively. At step 88, these were combined with AND. The results were filtered for English language studies. There were no date restrictions on the search.

Appendix 2. Example of completed data extraction form

<table>
<tr><td>Reviewer initials: NY</td><td>Today’s date: 05/07/17</td><td>Unique study number: 5</td></tr>
<tr><td colspan="2">Article title: Effects of watching aquariums on elders' stress</td><td>Year published: 1990</td></tr>
<tr><td colspan="2">1st author: DeSchriver</td><td>Publication type: Original article</td></tr>
<tr><td colspan="3">Publication title: Anthrozoos</td></tr>
<tr><td colspan="3">URL: http://www.tandfonline.com/doi/pdf/10.2752/089279391787057396</td></tr>
<tr><td colspan="3">Study Question(s)/Aim(s)/Objective(s)/Hypotheses: To determine whether viewing real fish or videos of fish can produce a relaxational effect or reduce physiological stress in elders.</td></tr>
<tr><td>Design: Three groups RCT</td><td colspan="2">Setting: publicly subsidised housing unit for elderly persons in Maryland, US</td></tr>
<tr><td rowspan="3">Sample size: 27
Age range (average): not stated
Sex: 21 females (78%), 6 males (22%)
Ethnicity: not stated

Detail any other relevant pre-intervention measures –for example gardening experience, health status, co-morbidities: None stated</td><td colspan="2">Recruitment procedure:
Not stated</td></tr>
<tr><td colspan="2">Random assignment to groups (Y/N/can’t tell/not applicable): Yes</td></tr>
<tr><td colspan="2">Unit of allocation to groups: at individual level</td></tr>
<tr><td>Number of groups:

Group 1
Exposure/intervention(s): Fish aquarium
No. participants: 9
Age range (average): median 75y
Sex: 8 female (89%), 1 male (11%)
Ethnicity: not stated

Group 2
Exposure/interventions(s): Fish video
No. participants: 9
Age range (average): median 73y
Sex: 7 females (78%), 2 males (22%)
Ethnicity: not stated

Group 3
Exposure/interventions(s): placebo video tapes (static)
No. participants: 9
Age range (average): median 76y
Sex: 6 females (67%), 3 males (33%)
Ethnicity: not stated</td><td colspan="2">Details of nature element(s):

The fish aquarium was a landscaped ten-gallon tank stocked with nine fish (two black mollies, two red wag swordtails, two gold wag moons, two pineapple swordtails, and one catfish).

The fish videotape was a modified version of a videotape produced by the Candle Corporation that showed (almost exclusively in close-up shots) a variety of colorful tropical fish swimming in an aquarium. The audio portion of the videotape was enhanced by superimposing the sound of a stream
trickling over rocks.

Study participants were tested individually
in the arts-and-crafts room of the apartment complex where they resided</td></tr>
</table>

	Frequency and duration of intervention(s): 8-minute session, once per week for 3 weeks
	Whole study duration: 3 weeks
	Year(s) study took place: not stated

Measures/instruments/tools	Statistical methods	Key results/effect sizes/findings
• Cognitive stressor – reading aloud an emotionally stimulating article for 3 min • Treatment Evaluation Scale constructed using a revised version of Beard and Ragheb's (1980) shortened Leisure Satisfaction Scale (LSS) • Cardiovascular activity as a proxy for physiological stress. Composed of pulse rate, skin temperature and musculoskeletal tension	Test for between-groups differences in the pre-post test score changes. The test(s) used is not stated but appears to be ANOVA.	TES mean scores: Fish aquarium: 12.33 Fish videotape: 12.89 Control: 12.23 Between-groups diff NS (F [2, 24]=0.08, p=0.93. <u>Pre & post-test mean scores</u> Pulse rate (bpm): Aquarium: 72.02 to 73.19 Fish video: 71.50 to 71.32 Control: 72.39 to 72.61 *F [2, 24]=0.50, p=0.24* Skin temp (degrees Fahrenheit): Aquarium: 94.08 to 94.23 Fish video: 91.16 to 91.81 Control: 91.92 to 91.98 *F [2, 24]=0.50, p=0.30* Muscle tension (mV): Aquarium: 23.46 to 21.40 Fish video: 26.24 to 24.04 Control video: 26.26 to 24.62 *F [2, 24]=0.37, p=0.35*
When were Measures/instruments/tools administered? Data were collected during all three sessions but only data collected during the third session was included in the analysis. The author stated that the first two sessions were necessary to 'acclimatise' participants to the conditions and avoid habituation.		

TES: post-test (after 3rd session) Physiological measures: pre-test (means of 2 readings taken 1 min apart) and post-test (means of 8 readings taken 1 min apart)		
Author-identified strengths The cognitive stressor wasn't used in the first two (acclimatising) sessions to control for possible habituation. No other activities were undertaken in the testing room during the study	Author-identified limitations Very small sample sizes	Author-identified conclusions They suggested the fish videotape has a greater impact on reducing stress than the aquarium. **But they don't** - the F scores showed no difference in effect across the 3 conditions for both the TES and the physiological measures.
Reviewer-identified strengths	Reviewer-identified limitations There were no analyses for within-group score changes on the physiological outcomes. The first line of the discussion says that aquarium viewers had a **decrease** in pulse rate. Table 1 shows it was an **increase**. Participants were heard "conversing with others between sessions about their favourite fish" – potential contamination? Extremely limited demographic information and no	Reviewer-identified conclusions All three conditions led to similar tiny increases in skin temperature and slightly larger decreases in muscle tension. Change in pulse rate was variable. But there were no significant differences between the groups for any of the physiological variables. Given the small sample size and lack of within-group analyses, it would be unreasonable to draw any conclusions about the ability of viewing a fish aquarium or fish videotape to induce

	consideration of how demographics might confound No information on reliability or validity of the TES Test-retest reliability for the EMG was poor (0.56) Only the measures analysed in the final week were taken for analysis.	relaxation/reduce stress in this population.
Funding source: not stated		
Conflicts of interest: not mentioned by the authors but the fish videotape was produced by the Candle corporation. This corporation also made a donation of “software equipment” to the group. Given the authors’ unsupported conclusions re the videotape working best, there may be some CoI here.		

Appendix 3. Descriptions of individual studies

Aslakson (2010) used a **RCT** to compare the ability of music therapy (their intervention, my comparator) and **nature videos** (their control, my intervention) to improve **agitation, engagement** and **functional behaviour (social interaction, task performance, problem solving)** in 40 nursing home residents in the Midwestern US. Three sessions of music therapy or nature videos, each 30-40 mins in duration, were delivered during one week. Pre and post-test measures were collected using the **Wisconsin Agitation Inventory (WAI)**, **Functional Behaviour Profile (FBP)** and an **Engagement** variable developed by the researcher. ANOVA and ANCOVA were used to assess between-group differences. Both groups experienced a significant decrease in agitation (music: 44.12 to 30.18; nature 42.64 to 33.82; $F=5.83$, $p<0.05$) but there were no significant between-groups differences. There was a significant between-groups difference in pre to post engagement scores (music: 3.3 to 4.5; nature: 3.4 to 2.3; $F=24.54$, $p<0.01$). There was a significant between-groups difference in the social interactions component of the FBS ($F=0.93$, $p<0.05$) but there were no descriptive statistics reported for this measure, so exact score changes, or direction of changes could not be determined. Conclusion: watching a nature video or taking part in music therapy sessions significantly improved agitation in people with dementia. Nature videos were associated with significantly decreased engagement. There was no information on the specific content of the nature video.

Barnicle and Midden (2003) and Midden and Barnicle (2004) used a **controlled clinical trial** to evaluate the effects of a **horticulture activity programme** on **psychological wellbeing (affect)** in 62 residents of two long-term care facilities in Missouri, US. The intervention group lived in facility 1, and received 1x 1hr guided horticulture session per week for 7 weeks. The control group lived in facility 2, received usual care, and was told the horticulture programme would start in 7 weeks (waiting list). The **Affect Balance Scale** tool was administered at pre and post-test. One-way ANOVA was used to assess within-group changes. Two-way ANOVA was used to test for between-group differences. The intervention group had a pre to post-test increase in mean ABS from 5.42 to 7.61 ($F=3.17$, $p=0.08$). The control group had a pre to post-test decline in mean ABS from 4.29 to 3.00 ($F=0.70$, $p=0.40$). The pre to post-test change in ABS score was significantly greater in the intervention than the control group ($F=6.78$, $p=0.01$). Conclusion: residents who took part in guided horticultural activities had a near-significant increase in psychological wellbeing over a 7-week programme.

Brown *et al* (2004) used a **cluster RCT** to examine the effects of **indoor gardening** on **socialization, activities of daily living (ADLs),** and **perceptions of loneliness** in 66 elderly nursing home residents of two facilities in the south-eastern US. The intervention group lived in facility 1 and received 1x indoor gardening session (duration not stated) per week for 5 weeks. The control group lived in facility 2 and received 20 minute visits from facility staff. The **UCLA Loneliness Scale (V3), Revised Social Provisions Scale** and **Minimum Data Set Physical Functioning Scale for ADLs** were administered at pre and post-test. There were significant within-group improvements for both groups in loneliness and several socialisation measures, but there were no significant between-group differences. The intervention group had significant improvements in three ADLs associated with upper body movement, but the equivalent results for the control group were not reported. In a second phase, the control group received a 2-week indoor gardening programme. This group's post-test scores did not significantly differ from their visits scores, and there were no significant within-group changes for this group during phase II. The 5-week gardening programme was significantly favourable over the 2-week programme on four socialisation subscales and two physical functioning scales. However, it was unclear which scores (post-test scores, pre-to-post change) were used in this latter analysis. Conclusions: A 5-week gardening programme was no more beneficial than 20 minute visits for improving several psychological and physical health outcomes in elderly nursing home residents. Some measures indicated that a gardening programme conducted once per week for 5 weeks was more beneficial to health than a programme conducted twice per week for 2 weeks.

Chung *et al* (2016) used **one-group pre/post design** to explore effects of **media presentations containing nature** on **agitated behaviours** of 23 dementia patients residing in a long-term care facility in Salt Lake City, US. Participants viewed nature DVDs for 7-10 mins, once per day, 3x per week for 2-4 weeks. Agitated behaviours through **daily nursing records**. MANOVA was used to compare these against baseline records taken 2 weeks prior to the study. Frequency of one behaviour type, 'hitting a resident' changed to a near-significant level during the intervention, but the direction and size of the change was not reported. Conclusion: in 6 out of 7 measures, short nature DVDs had no effect on agitated behaviours in dementia patients. The effect on 'hitting a resident' was unclear.

Cohen-Mansfield and Werner (1998) employed a **quasi-experimental crossover** design to assess the effects of two **simulated enhanced environments** on **behaviour, mood, and pacing/wandering** of 27 nursing home residents who pace frequently. The home's location was not specified. Following a 2-week baseline data collection period, 'nature' and 'home' scenes were erected in separate corridors. The scenes were rotated, and were in place for a total of 4 weeks over a period of 6 weeks. The **Confusion Inventory**, **Lawton's Modified Behaviour Stream** (mood) and **Cohen-Mansfield Agitation Inventory**, as well as direct researcher observations of participants' **location, body position, pacing/wandering, exit-seeking and trespassing** behaviours were employed during scene and no-scene periods. Location and exit-seeking, trespassing, and pacing/wandering were also recorded with **automatic counting** and **ambulatory tracking devices**, respectively. Baseline/no-scene vs scene scores were compared using t-tests and Wilcoxon alpha. When either enhancement was in situ, participants exhibited (non-significantly) less lying down, exit-seeking and trespassing. During the nature enhancement, participants additionally exhibited less sleeping, and during the home enhancement, they additionally exhibited less pacing and less standing. A significant increase in the mood sub pleasure was observed between no-scene and nature (1.05 v 1.11, $p<0.05$), but not the home scenes. For participants who displayed agitated behaviours during baseline, large reductions in frequency of agitation episodes occurred in three of four agitation categories for nature, and two of four categories for home. No between-groups statistical comparisons were made for any measures. Conclusion: A nature scene enhancement was associated with fewer instances of agitated behaviour, less time sleeping and increased pleasure compared with home scenes, but several other behaviours, including exit-seeking and trespassing, were similar for both enhancements. Pacing/wandering only decreased in the home enhancement.

Collins and O'Callaghan (2008) used a **one-group pre/post** design to study the effects of a **horticulture activity programme** on **psychological wellbeing** in 18 residents of a low-income assisted living facility in Nevada, US. Participants attended 2-hour interactive horticulture classes once per week for 4 weeks. The quantitative part of the study employed **Pearlin & Schooler's Mastery Scale** and **self-reported health** and **self-reported happiness** were each scored with 1 item. Measures were taken pre (t1) and post-test (t2), and additionally at 5-month follow-up (t3) for a subset of participants. Paired t-tests were used to analyse differences in scores between each of the time points. There were significant improvements in personal mastery from t1-t2 (t= -6.75, p=0.001), t1-t3 (t= -4.07, p=0.005), and near significant improvement from t2-t3 (t= -2.0, p=0.086). There were significant improvements in self-reported health from t1-t2 (t= -4.12, p=0.001), t1-t3 (t= -3.99, p=0.005), and t2-t3 (t= -0.75, p=0.02). There were significant improvements in self-rated happiness from t1-t2 (t= 2.2, p=0.042), t1-t3 (t= -2.65, p=0.033), and near-significant improvements from t2-t3 (t= -2.05, p=0.08). Conclusions: A short-term horticulture intervention including taking personal responsibility for plants seemed to be beneficial for participants in terms of three wellbeing and quality of life measures: perception of personal mastery, self-reported health and self-rated happiness. However, the lack of control group means effects are not certainly attributable to the intervention.

DeSchriver and Riddick (1990) used a **three-group RCT** to examine the ability of viewing real fish in an **aquarium tank**, watching **videos of fish**, or watching videos of static to induce **relaxation** and reduce **physiological stress** in 27 elders living in a publicly subsidised housing unit in Maryland, US. Participants attended sessions for 8 minutes once per week for 3 weeks. Cardiovascular activity was taken as a proxy for physiological stress, including **pulse rate, skin temperature** and **muscle tension** and was measured before and after each session. Only results from the third session were analysed. The statistical test was not stated, but between-group post-test comparisons were made for each measure, controlled for pre-test scores: there were no significant differences. There were also no significant within-group changes in any measures from pre to post test. Conclusion: Neither a fish aquarium or fish videotape was able to reduce physiological stress levels when viewed in 1x 8-minute session.

D'Andrea *et al* (2008) used a **RCT** to determine whether a **horticulture therapy programme** could slow **cognitive decline** in a sample of 40 nursing home residents with Alzheimer's disease living in a dementia special care unit in New York, US. Half the participants were randomly assigned to receive 30-45 minutes of indoor horticultural activities twice per week for 12 weeks. The other half served as controls, and continued regular scheduled activities which included music sessions, reminiscence discussion and socialising. **Minimum Data Set Plus (MDS+)** was administered 'throughout the study' and **Test for Severe Impairment (TSI)** was employed pre and post-test. No data for the MDS+ was reported, but the authors indicated improvements in functional level, mood, behaviour, ADLs and wellbeing among all participants in the horticulture group. TSI scores slightly improved from pre to post-test in the horticulture group (19.5 vs 20.4) but worsened in the controls (21.5 vs 19.5). Because the baseline scores significantly differed, an independent t test was conducted on the difference scores (generated by subtracting the post-test scores from the pre-test scores). The results showed a significant difference between the groups ($t=5.7$, $p<0.0005$). Conclusion: Taking part in a 12 week HT programme was associated with maintenance of cognition in people with AZD.

Edwards and Beck (2002) used a **controlled quasi-experiment** to study the influence of **fish aquariums** on **nutritional intake** and **body weight** in 62 elderly individuals with Alzheimer's Disease living in three dementia-specific units in Indiana, US. An aquarium was installed in the dining room of facilities 1 and 2 for eight weeks. A scenic ocean picture was installed in the dining room of facility 3 (control) for two weeks. Following a washout & further baseline period, facility 3 switched to the aquarium condition for eight weeks (waiting list). Participants were exposed to the installations during mealtimes (3x per day). **Body weight** was measured once per month, starting from 3 months prior to the start of the intervention. Nutritional Intake was operationalised as the **weight of food consumed** (in grams) at mealtimes and was measured at every meal (3x per day) during baseline and for the first 2 weeks of the aquarium, and then once weekly for the remaining 6 weeks. Paired t-tests were used to assess within-group changes in mean nutritional intake between baseline and treatment. In the intervention group nutritional intake: 1) increased 21.1% from baseline to the end of the two-week period in which measurements were taken daily (all facilities combined t score -7.276, $p<0.001$) and 2) increased 27.1% between baseline and the end of the 6 weeks in which measurements were taken weekly (t score -7.932, $p<0.001$). There were no significant changes in nutritional intake within the control group. The statistical test used to analyse change in weight was not stated. There was a significant increase in intervention group weight in the month the aquarium was introduced (M: 0.54 Ibs) and over the four months since introducing the aquarium (1.65 Ibs, $p<0.001$) No information was given about weight for the control group. There were no between-group comparisons for either measure. Conclusion: introducing an aquarium into the dining room of a dementia facility may lead to increased nutritional intake and body weight, but the lack of comparison with the control group means this is not certain.

Edwards and Beck (2013) used a **one-group pre/post** design to assess the influence of viewing an **aquarium** at mealtimes on **food intake** and **body weight** of 70 elderly individuals with dementia living in three specialised dementia units in North Carolina, US. An aquarium was introduced into the facility dining room for 8 weeks and was visible to all participants during mealtimes. Body weight was measured once per month, beginning 3 months prior to the start of the intervention and continuing for 3 months afterwards. Food intake was operationalised as the **weight of food consumed** (in grams) at mealtimes and was measured at every meal (3x per day) during the baseline period (phase I), once per day during the first 2 weeks (phase II) of the intervention, and once per week for the remaining 6 weeks (phase III). Mealtime scores were averaged to produce mean daily food intake, and then daily intakes were averaged across each phase. Mean increase in food intake was 121.6 g between phases I and II (a significant increase) and 75.3 g (a non-significant increase) between phases II and III, making a total mean increase of 196.9g (a 25% increase) over the 10-week period. Repeated measures ANOVA found a significant main effect of phase on total food intake ($F=85.7$, $p<0.001$). Paired t tests with Bonferroni correction were employed to examine changes in body weight. A significant increase of 2.2 pounds ($t=7.5$, $P=0.000 <0.05/3$) occurred between the mean baseline weight (158.4 pounds) and the mean weight at the end of phase III (160.6 pounds). Conclusion: introducing an aquarium into the dining room of a dementia facility may lead to increased food intake and body weight, but the lack of control group means effects are not certainly attributable to the intervention.

Edwards *et al* (2014) used a **one-group pre/post** design to examine influence of an **aquarium** on **behaviour** and **psychological symptoms** of 71 people with dementia living in specialised dementia units in North Carolina and Florida, US. Following a 2-week baseline data collection period, an aquarium was placed in the activity room to be visible at mealtimes for all residents over the course of 8 weeks. An adapted version of the **Nursing Home Disruptive Behaviour Scale** was employed pre and post-test. Repeated measures mixed-model ANCOVA was used to examine pre to post-test changes. Overall behaviour scores significantly improved (mean 67.2 vs 58.2, F=15.6, p<0.001). Changes were significant along 4 behaviour domains: uncooperative (F= 4.76, p=0.033), irrational (F= 9.29, p=0.003), sleep (F=4.62, p=0.035) and inappropriate (F12.36, p=0.001), nearing significance for annoying behaviour (F= 3.81, p=0.055) and non-significant for dangerous behaviour. Conclusion: aquariums placed in a central location were associated with a significant decrease in problematic behaviours overall, and in four of six behavioural domains. A decreasing trend was observed in one additional behavioural category. The lack of control group means effects are not certainly attributable to the intervention.

Eggert *et al* (2015) used a **two-group quasi within-subject** design to assess whether viewing **preferred nature images** or **preferred music** impacts on **cognitive ability**, **engagement** and **dementia-related disordered behaviours** of 13 residents of a memory care unit. The location was not specified. Participants firstly selected one nature image from a selection representing themes from Appleton's Prospect Refuge Theory, or one song from a selection of genres. They then looked at and talked about the image, or listened to and sang along with the song, with the researcher, in 90 minute one-to-one sessions, once per week for 4 weeks. The **Individualized Dementia Engagement and Activities Scale (IDEAS)** and **Cohen-Mansfield Agitation Inventory (CMAI)** were used at the start and end of each session. **The Montreal Cognitive Assessment (MoCA)** was used one week before and one week after the intervention period. Descriptive analysis was undertaken. For the MoCA clock-drawing, one participant's score improved from 1 to 2. There were no improvements in the music group. For the MoCA memory recall, three of nine participants (33%) scored 2 points or more before the nature intervention compared with four of eight (50%) afterwards. Zero of four scored 2 points or more before the music intervention, compared with two of six (33.4%) afterwards. On the IDEAS, there were very small increases of between 0.7-1.8 points during each session for both interventions. Only two items from the CMAI, relating to verbally aggressive behaviours, were reported, and patterns were inconsistent across sessions for both interventions. Conclusion: The small sample size and mixed results meant the evidence from this study was insufficient to suggest that preferred nature images or music can affect agitation, engagement and cognition in persons with dementia.

Goto *et al* (2014) used a **controlled quasi-experiment** to determine the relative effects of a Snoezelen room and **indoor Japanese garden** on **behaviour** and

physiological stress levels of 36 nursing home residents with Alzheimer's and other forms of dementia living at a nursing home in New Jersey, US. Participants entered the environments for 15 minutes twice per week for 3 weeks (Snoezelen) or 4 weeks (garden). The interventions were separated by one year. Six participants experienced both environments. Physiological stress was operationalised as **pulse rate** and was taken during each session and post-session in the participant's own rooms. **The Behavioural Assessment Checklist** was taken during each session. T-tests, Chi^2 and one-way ANOVA were used to test effects of the interventions. Significantly more participants remained awake in the garden than the Snoezelen room (mean 12.63 vs 2.5, t=11.18, p<0.001). Significantly more participants moved around in the garden than the Snoezelen room (X^2=50.44, p<0.001). Fewer participants chose to leave the garden than the Snoezelen room. The percentage of verbalisations in the garden room was higher (56%) than the Snoezelen room (24%). Affect and attention were not compared statistically, but more of the garden participants showed positive affect (bright, smile), whereas level of attention paid to the setting was generally higher in the Snoezelen room – notably the researchers observed that most attention was paid to a nature projection. There was an almost continuous decrease in average pulse rate in the garden of approximately 0.15-0.2 beats per minute. By contrast, pulse rate in the Snoezelen room was more variable, with an overall average increase of 0.06 beats per minute. Comparing the last 6 minutes in the garden with post-test measures taken in participant's own rooms, garden pulse rates were significantly lower (p=0.034). There was no difference for the Snoezelen group in this respect (p=0.34). Regression to the mean may have been involved but this pattern did occur in the six participants who experienced both conditions. The study included a control group by taking 15 participants back to the garden location after it was dismantled, but no quantitative data for this group was reported. Conclusion: being in a Japanese garden appeared to somewhar reduce physiological stress (pulse rate), increase willingness to participate and improve verbalisations compared with a Snoezelen room.

Kieffer (2014) used a **cross-sectional** design to determine whether **images containing representational elements of nature** (REN) could increase perceived **self-reported wellbeing** in 20 residents of a senior independent living community in Minnesota, US. Participants viewed 4 pairs of photographs of senior living facilities public lounges. In each pair, one photo contained REN (water, fire, botanical motifs, natural materials) and the other did not. The participants answered a **questionnaire designed by the researcher** which ascertained how they thought they would feel if they were in the environments depicted. Perceived wellbeing was on five scales: refreshed – exhausting, distracted – attentive, relaxed – harried, irritable – patient and comfortable – uneasy. Descriptive analysis was undertaken. Pictures containing water were perceived as better for wellbeing than pictures without water on all five scales. Pictures containing natural materials were perceived as worse for wellbeing than pictures without natural materials on 4/5 scales. Results for fire and botanical motifs were mixed. Conclusions: Images depicting care home interiors containing water were perceived as better for wellbeing than images of interiors without water.

Kiyota (2009) used a **three group cluster RCT** to examine whether active or passive interaction with **indoor plants** would impact on **perceived restoration**, **helplessness** and **depression** in 30 residents of an elderly care facility in Canada. Plants were placed in the living room of six houses for 6 weeks. The plants were cared for by staff in three of the houses (passive group) and the residents in the other three (active group). Three further houses did not have plants and served as the control group. The active group participants also received 5 minutes of **horticulture tutoring** per week from the researcher. The **Modified Perceived Restoration Scale** and **Geriatric Depression Scale** were administered during baseline and once per week during the intervention. A mixed ANOVA was used with timepoint (x7) and group (x3) as factors. There were no significant group or time effects on perceived restoration, but a significant group x time interaction occurred (F 2.115, p=0.023). No post-hoc tests were performed but the mean PRS scores for the active group increased to a greater extent than the passive group. There were no significant effects of group, time or group x time on GDS. However, there was a trend of reducing scores over time for both the active and passive groups. Conclusion: Exposure to indoor plants had a significant positive effect on perceived restoration, and a positive trend in improving depression. Having active involvement in caring for plants was more beneficial than simply observing them.

Lee and Kim (2008) used a **one-group pre/post design** to determine the effect of an **indoor gardening programme** on **sleep, cognition** and **agitation** in 23 dementia patients living in an institution (location not specified). Participants took part for 1 hour twice per day every day for 28 days, and could also access their plants whenever they wanted. The **Modified Cohen-Mansfield Agitation Inventory** and 24-hour sleep diaries were collected every day during week 1 (baseline) and week 5 (final gardening week). The **Hasegawa Dementia Rating Scale - Revised** was employed once in week 1 and once in week 5. Paired t-tests were used to analyse pre/post-test changes. Significant pre to post-test improvements were observed in wake after sleep onset duration (75.22 vs 54.65 mins, t 2.781, p=0.011) and frequency (6.08 vs 2.21 occasions, t 3.568, p= 0.002), nap duration (158.43 vs 85.87 mins, t 7.933, p= <0.001) and frequency (3.18 vs 1.95 occasions, t 6.480, p=<0.001), Nocturnal Sleep Time (440.48 vs 483.52 mins, t -3.493, p=0.002), Nocturnal sleep efficacy (85.09 vs 89.62%, t -3.048 p=0.006), agitation (5.09 vs 3.13, t -4.002, p=0.001) and cognition (13.70 vs 17.48, t 12.044, p<0.001). Conclusion: participating in an indoor gardening programme was associated with improved sleep and cognition and reduced agitation in dementia patients. The lack of control group means effects are not certainly attributable to the intervention.

Martin (2011) used a **cluster-randomised crossover experiment** to determine whether **viewing landscape photographs** could reduce **agitation**, and whether there would be a dose-response effect in 22 nursing home residents with Alzheimer's and a history of agitation in New York, US. Each wing was allocated to display landscape photos (experimental) or photos depicting the interior of their nursing home facility (control). Slide shows containing 180 photos were projected on a loop in a public area of the wing for five days between 9am and 5pm. Following a washout period of 9 days, the conditions were switched. **The Brief Agitation Ratings Scale** was employed at baseline, during the viewing periods and during the washout period. **Dose** was operationalised as the number of minutes the participant was within the perimeter of the display, regardless of whether they were looking at it. Two-sample t-tests or Mann Whitney U tests were performed to assess effects of treatment, time period, treatment by time period and first-order carryover. The group which saw the experimental display first was denoted EC. The group which saw the control display first was denoted CE. There was an overall downward trend in scores (i.e. overall agitation improved) in both groups throughout the course of the study. There was no significant treatment effect (*t*=0.97, p=0.34), period effect (*t*=1.96, p=0.07) or carryover effect (*t*=-0.68, p=0.50). There was a significant time by period interaction (*t*=2.52, p=0.02), but this was lost with a supplemental calculation which adjusted for scores from the periods immediately before the experimental display periods (*U*=45, P=0.33). After dropping outliers, agitation decreased as dose increased, and this was significant when fitted with a linear model (R^2=0.15, *F*=4.45, p=0.05). However, as with the main analysis, significance was lost when adjusting for scores from the periods immediately before the experimental display periods. Odds of improvement in the experimental condition were approximately 12x greater for females than males (OR=12.00, p=0.04) and 5x greater for mild-moderately agitated participants than moderately-highly agitated participants (OR=4.67, p=0.09). Conclusion: there were no significant improvements in agitation between the nature and control condition.

Masuya *et al* (2014) used a **controlled pre/post quasi experiment** to determine the effect of a **horticultural activities programme** on **cognitive, psychological and physical functioning and QoL** of 18 elderly nursing home residents. The home's location was not specified. The intervention group (n=9) received 30-40 minutes of horticulture activity once per week for six weeks. The control group (n=9) were recruited from a different floor of the nursing home, and received routine care. **The Vitality Index (VI), Geriatric Depression Scale (GDS-15), Activities of Daily Living Scale (ADL-20), Mini Mental State Exam (MMSE)** and a **Visual Analogue Scale for QoL** were employed pre and post-test. Two-way ANOVA with Bonferroni correction was used for within and between-groups testing. GDS-15 score improved in the intervention group from pre to post-test (5.7 vs 3.6, F=14.01, p<0.05), and a time x group interaction occurred (F=8.12, p<0.05). The QoL item 'satisfaction with life' improved in the intervention group from pre to post-test (75.6 vs 91.1, F=28.00, p<0.05) and a time x group interaction occurred (F=16.46, p<0.05). No significant pre/post-test changes occurred in any other measure for the intervention group. No significant pre/post-test changes were seen in any of the measures for the control group. No other between-group differences or interactions were found. Conclusions: Participation in a horticultural activities programme significantly improved short-term depression and satisfaction with life scores in a small sample of elderly nursing home residents.

Moyle *et al* (2018) used a **one-group pre/post** pilot study to explore the effects of a **Virtual Reality forest** on **emotions, apathy** and **engagement** of people with dementia living in two residential care facilities in Australia. The intervention consisted of a large immersive wall-mounted TV screen depicting a forest scene. Video game technology allowed participants to interact with and influence the forest elements by moving their hands and arms. Ten participants were invited to take part in one session lasting up to 15 minutes. The outcomes were measured before, during and after the intervention. Emotion and apathy were recorded using the **Observed Emotions Ratings Scale** (OERS) and **Person Environment Apathy Rating** respectively. Each participant's engagement was coded into three types: (a) self-engagement: the resident engages in the activity without encouragement; (b) facilitated engagement: engagement in the activity is encouraged and supported by another person; and (c) no engagement: the resident is not engaging in the activity. The average duration of time spent in each type of engagement was used to describe engagement of the participant. The OERS ratings at pre, during and post-test were not compared, but the authors compared them to ratings previously established for people with dementia in an activity context. They reported scores were significantly higher for pleasure (p=0.008) and alertness (p<0.01) but not for sadness and anger. In addition, 50% of residents showed significantly higher fear. Apathy scores were significantly lower during the intervention (12.10), than before (18.30, *p*=0.01) or after (18.70, *p*=0.005). Participants spent an average of 10 minutes engaged in the Virtual Reality forest, and there were no differences in durations spent in the three different types of engagement. Conclusions: this pilot study suggests immersion in a Virtual Reality forest could be useful for increasing pleasure and alertness and reducing apathy in people with dementia, and a larger study should be undertaken to evaluate its effectiveness.

Powell *et al* (1979) used a **controlled crossover** design to determine whether taking part in an **indoor gardening programme** could increase **engagement** in 32 residents of a local authority nursing home in Hampshire, UK. Residents who habitually sat in one of two lounges were chosen to be involved. Gardening sessions were delivered on one day per week for 10 weeks ('gardening days'). Residents could choose on each gardening day whether to attend the session or not. Whether or not they attended, their **engagement** level was observed at three minute intervals (total duration not stated). Participants were **recoded as engaged** if they were interacting with another person, using recreational materials, using materials connected with daily living activities or moving around using mobility equipment. If a participant did not attend the gardening session, engagement was measured in the lounges. Engagement was additionally measured for all participants on another day each week ('non-gardening days') whilst they were in the lounges. The number of participants who were engaged and the number being observed were calculated to produce a % engagement score for each day. The average attendance at the gardening sessions was 6.1 residents per session (range: 3-9). Over the course of the study, 12 different residents attended the gardening sessions. Engagement in the gardening sessions was consistently high, averaging 90%. Engagement in the lounges was consistently low, averaging 30% on non-gardening days and 31% on gardening days. A one-tailed t-test found that total engagement (including measures taken from participants in the lounge) was 43% on gardening days and 31% on non-gardening days (p<0.005). Engagement in the gardening sessions remained high (79%) at a 4-month post experimental timepoint. Conclusion: The engagement level of a selected portion of low-activity residents in a care home was significantly higher on days when an indoor gardening intervention was run.

Reynolds *et al* (2018) used a controlled crossover design to determine whether exposure to a **virtual nature experience** could reduce **agitation, anxiety** and **heart rate** for 14 people with dementia living in memory care units of an assisted living facility (location not specified). In one condition, residents watched a nature film depicting a mountain scene with a stream, accompanied by nature sounds. In the control condition, they viewed a generational movie. The film/movie were both shown on a 65 inch TV, in a small room, which was intended to increase feelings of presence in the experiences. Participants experienced both conditions three times in a counterbalanced design. There was a washout period of one day between conditions and one week between each of the three trials. Participants were required to stay in the room for at least ten minutes, but could stay longer if they wanted. The outcomes were measured with the **Observed Emotions Ratings Scale (OERS)**, **Agitated Behaviour Scale,** and **pulse oximetry** were administered at pre- and post-test. Repeated measures ANOVA was used to test for main effects and interactions. Heart rate significantly decreased from pre- to post-test in the nature condition (78.3 to 69.8 bpm, *p*=0.03) but not in the control condition (75 to 74.6 bpm, *p*=0.715). There was a significant time x treatment interaction effect (p=0.012). There were significant decreases in agitation and anger in both conditions, but no between-group differences. There was a non-significant decrease in pleasure in the nature condition (3.7 to 3.5, *p*=0.37), but a significant increase in the control condition (3.8 to 3.3, *p*=0.04), and a significant interaction between time and condition emerged (*p*=0.027). There were no significant effects for other OERS subscales of alertness, sadness or anxiety. Conclusion: virtual nature experiences may be a cost-effective way of increasing pleasure and decreasing stress for people with dementia.

Riddick (1985) used a **three group controlled pre/post quasi experiment** to determine whether owning a goldfish **aquarium** would significantly improve **blood pressure, happiness, anxiety, loneliness** and **leisure satisfaction** in a sample of 24 non-institutionalised elderly people. Residents of a low-income public subsidised apartment complex in the US were non-randomly assigned to aquarium, visits or control group. Aquarium participants had an aquarium containing two goldfish installed in their home. Researchers also visited the aquarium group ten times, once fortnightly for 25-40 minutes to help clean/maintain the tanks and talk about the fish. The visits group had visits only, and could choose what to do - most opted for socialising and watching television. The control group did not receive an aquarium or visits. **Memorial University of Newfoundland Scale of Happiness (MUNSH)**, the Trait A Scale of the **State Trait Anxiety Inventory (STAI), UCLA Loneliness Scale, Leisure Satisfaction Scale** and **blood pressure readings** were gathered pre and post-test. **The alpha level was set at 0.30**. T-tests were used for diastolic blood pressure, as baseline scores significantly differed. Diastolic bp significantly decreased from pre to post-test for the aquarium (82.00 vs 74.57, *t*=2.60, p=0.04) but not the visitor (72.25 vs 69.50, *t*=0.96, p=0.37) or control (78.86 vs 76.00, *t*=0.46, p=0.66). No between-groups comparisons were made. ANOVA was used for all other measures. Leisure satisfaction increased from pre to post test for the aquarium group relative to the other two groups (*F*=1.35, p=0.28). The aspect of the scale which improved most for aquarium vs the other groups was relaxation (*F*=3.17, p=0.06).The visitor group experienced a decrease in loneliness (*F*=2.86, p=0.08) compared to the other groups. There were no between group significant differences in any other measures, though systolic bp decreased in the aquarium and visitor groups, but not in controls. Conclusion: owning a fish aquarium may help reduce blood pressure and improve relaxation in some community-dwelling older adults. However, this study needs to be repeated with random allocation and testing at the 0.05 significance level.

Scott *et al* (2014) used a **three-group cluster-randomised ABA** design to determine the relative effects of a **biophilia installation** and a reminiscence installation on a range of health and wellbeing outcomes in 33 residents of three aged-care facilities in Australia. Each facility was randomly assigned to receive a **biophilia intervention,** a reminiscence intervention (objects, furniture and décor from the 1920s-1950s) or to control (no installation) for four weeks. **Satisfaction with living environment, satisfaction with opportunities for keeping occupied**, and **social engagement** were assessed using questionnaire items specifically constructed for this study. **Geriatric Depression Scale** short form (GDS-5), **Geriatric Anxiety Inventory** short form (GAI-SF), and the **Quality of Life - Alzheimer's Disease** (QoL-AD) assessment tool were also employed. All tools were used at baseline (T1), during the intervention (T2) and during the two weeks after the intervention (T3) except QoL which was only measured at baseline. ANOVA, MANOVA and follow-up t-tests with Bonferroni correction were used to ascertain between group differences. A significant time x condition interaction occurred for social engagement (F=2.85, $p<0.05$). There were no differences at T1, but at T2, social engagement was significantly better in the biophilia (2.17) and reminiscence (2.42) groups than the controls (2.98) - NB lower scores mean better social engagement. Similar results were seen at T3. There were no significant differences between the biophilia and reminiscence conditions at any time point. There were no significant time or group effects for any other measure. However, there was a trend for satisfaction with living environment and satisfaction with opportunities for keeping occupied to increase during the intervention period in the biophilia group, but not the other groups. Conclusion: a 4-week biophilia or reminiscence installation significantly improved social engagement in a sample of residents living in aged-care facilities.

Talbot and Kaplan (1991) used a **cross-sectional questionnaire** to explore whether taking part in **indoor 'compensatory' nature activities** was associated with life satisfaction and residential satisfaction in a sample of 48 residents of an apartment complex for the elderly in Michigan, US. As part of a broader questionnaire about access to and perceptions of importance of nature, respondents were asked: "how much do you do each of the following?" 1) look at nature photographs or drawings, 2) watch nature programmes on TV, 3) use nature themes in decorating or when buying greetings cards. Answers were given on a 1-5 scale where 5=very often. They also answered the **Life Satisfaction Scale** and **Residential Satisfaction Scale**. Descriptive statistics were used. Mean scores were for the compensatory nature involvements were: 3.6/5 for looking at nature photographs, 3.5/5 for watching nature programs on TV, and 3.6/5 for using nature themes in decorating. T tests found that neither life satisfaction nor residential satisfaction scores were associated with the degree of compensatory nature involvements (data was not shown), but they were related to outdoor nearby nature. Conclusion: While one can read about nature, look at nature photographs or watch nature programs on TV, these compensatory activities do not relate to improved life or residential satisfaction.

Tse (2010) used a **cluster RCT** to explore whether an **indoor gardening programme** would impact on **activities of daily living (ADLs), socialisation**, **loneliness** and **life satisfaction** of 53 older people living in four nursing homes in Hong Kong. Two homes were assigned to the intervention group to take part in an indoor gardening programme once per week for 8 weeks. The other two homes were assigned to the control group, and received usual care including regular visits. **Life Satisfaction Index-A (Chinese version) (LSI-A), Revised UCLA Loneliness Scale (Chinese version), Lubben Social Network Scale (LSNS) and Modified Barthel Index (MBI)** were employed pre and post-test. Chi-square, Wilcoxon and spearman tests were variously used to test for differences between groups. The gardening group had significant pre-post improvements in all psychological measures: social network (19.27 vs 24.77, p<0.01), life satisfaction (11.73 vs 15.73, p<0.01), loneliness (41.38 vs 35.46, p<0.01), but not in ADL (107.19 vs 107.19, p=1.00). There were no significant pre/post-test changes in the control group. The post-test scores for the gardening group were significantly better than the control group for all measures (p<0.001) except ADL, for which there was no difference (p=0.06). Conclusions: Taking part in an 8-week indoor gardening programme significantly improved three psychological outcomes (but not activities of daily living) for older adults living in nursing homes.

Webster (2015) used a **one-group ABABB** design to study effects of **indoor plants** on **cognitive function** and **behaviour** of people with dementia in 11 residents of a continuing care facility in North Carolina, US. Plants were placed in frequently used common areas on day 1, were removed after day 6, replaced on day 8 and remained in place until final removal on day 15. Revised versions of the **Time and Change** and **Trail-making tests**, an attention task from the **Montreal Cognitive Assessment**, and a **colour recognition** task were used to assess cognitive function. **Dementia Care Mapping** was used to record behaviours, specifically 1) ill/wellbeing and 2) interactive (categorised into high potential, agitated and withdrawn). Measures were taken on day 1, 6, 8, 13 and 15. The overall **proportions** of improving scores and declining scores between various time points were compared. On the whole, cognition improved between day 1 and 6, and between day 8 and 15 (i.e. from baseline days to final plant days). Cognition was higher on day 6 (a final plant day) than day 8 (two days after plant removal). Ill/wellbeing and agitation remained relatively unchanged throughout. There was a tendency for high potential behaviours to decrease and withdrawn behaviours to increase during the plant periods. Conclusion: this study provides some support for the role of indoor plants to enhance cognitive ability in continuing care facility residents with dementia, but there seemed to be a negative association with behaviour.

Yao and Chen (2017) used a **controlled pre/post quasi-experiment** to test the effects of a **horticulture therapy programme** on **activities of daily living (ADLs), happiness, meaning of life and interpersonal intimacy** of 85 residents of 7 nursing homes in Kaohsiung, Southern Taiwan. The intervention group received 1 hour of horticulture therapy once per week for 8 weeks. The control group received usual care and was told they would have the opportunity to take part in the programme in due course (waiting list). **Barthel Index (BI), Chinese Happiness Inventory short form (CHI), Meaning of Life Scale (MLS)** and **Interpersonal Intimacy Scale (IIS)** were used pre and post-test. Paired t-tests were used to make within-group comparisons. ANCOVA was used to compare between-group post-test differences whilst controlling for pre-test differences as a covariate. The intervention group's scores significantly improved from pre to post-test on ADL (62.44 to 67.32, t:-2.04, p=0.048), happiness (11.07 to 14.02, t:-5.09, p<0.001), meaning of life (74.49 vs 76.61, t:-3.25, p=0.002) and interpersonal intimacy (44.49 vs 48.39, t:-3.28, p=0.002). Meaning of life scores also improved for the controls (p=0.045) but decreased for happiness (p=0.002) and for ADL (p=0.059). Baseline scores between groups were not significantly different, but the intervention group had significantly better post-test scores than controls on ADL (70.80 vs 58.79, F=11.89, p=0.001), happiness (14.15 vs 7.86, F=59.18, p<0.001), interpersonal intimacy (49.24 vs 43.79, F=16.55, p<0.001) but not meaning of life (76.47 vs 76.19, F=0.11, p=0.738).

Conclusion: Participating in horticultural activities significantly improved ADL, sense of happiness and interpersonal intimacy for older adults living in nursing homes.

Appendix 4. Detailed study outcomes

First author, year	Study design (quality appraisal score)	Intervention(s)	Control(s)/ comparator(s)	Tool	Within-group changes	Between-group differences
Dementia-specific outcomes						
Cognition						
D'Andrea, 2008	RCT (strong)	Horticulture Therapy programme	Various regular scheduled activities e.g. music sessions, reminiscence discussions, socialising	TSI[a] MDS[a]	TSI I: 19.5 to 20.4 C: 21.5 to 19.5 MDS+ NR	I>C for pre to post score change (0.84 vs -2.0, t=5.7, p<0.0005)
Masuya, 2014	CCT (weak)	Horticultural activity programme	Usual care	MMSE[b]	No main effect of time (F=1.41, p>0.05) I: 23.1 to 23.4 (F=3.21, p>0.05) C: 24.3 to 24.2 (F=0.13, p>0.05)	No main effect of condition (F=0.36, p>0.05) No condition x time interaction (F=1.09, p>0.05)
Eggert, 2015	Within-subjects quasi-experiment (weak)	Preferred nature images (photographs)	Preferred music	MoCA[a]	I: three of nine participants (33%) scored 2+ at pre-test compared with four of eight (50%) at post-test. C: zero of four participants (0%)	NR

					scored 2+ points at pre-test compared with two of six (33.4%) at post-test No stats performed.	
Lee, 2008	One-group pre/post (moderate)	Indoor gardening programme	N/A	HSD-R[a]	13.70 to 17.48 (t=12.044, p<0.001)	N/A
Webster, 2015	One-group ABABB (weak)	Indoor plants	N/A	1) Revised Time and Change Test 2) Revised Trail-making Test 3) MoCA[a] 4) Colour recognition task constructed for the study Measures collapsed into one score	Reported as proportion of scores changing between time points. From 1st baseline to 1st plant exposure: 28.8% of scores improved, 48.8% were unchanged, 22.5% declined. Similar patterns seen between 2nd baseline and 2nd exposure and 2nd baseline and 3rd exposure. No stats performed.	N/A
Agitation						

Aslakson, 2010	RCT (weak)	Nature videos	Music therapy	WAI[b]	Significant improvements in both groups ($F=5.83$, $p<0.05$) I: effect size 0.46 C: effect size 0.33	No significant time by condition interaction ($F=0.04$, $p=0.84$) ES between I & C: $\eta^2= 0.001$ (no effect)
Reynolds 2018	Quasi-crossover (moderate)	Nature film	Generational movie	Agitated behaviour scale[b]	Significant improvements in both groups (both 15.7 to 14.9, $p=0.003$)	NS
Martin, 2011	Cluster-randomised crossover (moderate)	Nature slide show looped corridor projection (180 photos)	Nursing home interiors slide show looped corridor projection (180 photos)	BARS[b]	No significant period effect ($t=1.96$, $p=0.07$)	No significant treatment effect ($t=0.97$, $p=0.34$) A significant treatment-by-period interaction ($t=2.52$, $p=0.02$) was lost on adjustment for baseline measures
Cohen-Mansfield, 1998	Quasi-crossover (weak)	Nature corridor enhancement	'Home' corridor enhancement	CMAI[b]	NS reductions in frequency of agitation episodes	NR

					occurred in three of four agitation categories for I, and two of four categories for C: Physical, nonaggressive (n=5) I: 27.76 to 17.60 C: 27.76 to 26.46 Physical, aggressive (n=2) I: 4.23 to 2.50 C: 4.23 to 0.00 Verbal, nonaggressive (n=5) I: 9.57 to 7.35 C: 9.57 to 9.74 Verbal, aggressive (n=6) I: 16.26 to 16:00 C: 16.26 to 13.27	
Lee, 2008	One-group pre/post (moderate)	Indoor gardening programme	N/A	Modified CMAI[b]	5.09 to 3.13 (*t* -4.002, p=0.001)	N/A

Chung, 2016	One-group pre/post (weak)	Nature media presentations (DVDs)	N/A	Daily Nursing Records	No means reported but all changes were NS: Hit a resident p=0.09 Hit a staff member p=0.58 Yelled/screamed p=0.34 Cursed/swore p=0.58 Experienced agitation to the point of interference with care p=0.52 Threw self on the floor p=0.55	N/A
Eggert, 2015	Within-subjects quasi-experiment (weak)	Preferred nature images (photographs)	Preferred music	CMAI[b]	Only results from Q9 and Q10 (verbally aggressive behaviours) are discussed: results were mixed for both conditions	NR
Other dementia-related behaviours						
Cohen-Mansfield, 1998	Quasi-crossover (weak)	Nature corridor enhancement	'Home' corridor enhancement	1) Direct observation 2) Ambulatory tracking device.	Direct observations: Pacing/wandering	NR

				Both reported as duration[b]	I: 137.60 to 137.11 C: 132.28 to 125.74 Trespassing I: 8.61 to 7.32 C: 8.69 to 5.82 Exit-seeking I: 0.34 to 0.20 C: 0.30 to 0.27 None were significant for either group Ambulatory tracking device: NS	
Aslakson 2010	RCT (weak)	Nature videos	Music therapy	FBP[a]	Social Interactions Means NR I: effect size 0.48 C: effect size 0.57	Social Interactions F=0.93, $p<0.05$, direction NR Task Performance and Problem Solving domains NS
Goto, 2014	CCT (weak)	Indoor Japanese garden	Snoezelen room	1) BAC[a]	NR	BAC: movement

				2) willingness to participate - recorded as either: absent, awake, asleep, leave, refuse. 3) frequency of verbalisations[a]		I>C (X^2=50.44, p<0.001) Verbalisations I>C (56% vs 24% of participants verbalised at least once) Stayed awake I>C (12.63 vs 2.5, t=11.18, p<0.001) No stats performed for any other measure.
Webster 2015	One-group ABABB (weak)	Indoor plants	N/A	Dementia Care Mapping	The proportion of participants exhibiting high potential behaviours tended to decrease and the proportion exhibiting withdrawn behaviours tended to increase when plants were in	N/A

					place. No stats performed.	
Edwards, 2014	One-group pre/post (moderate)	Fish aquarium	N/A	Nursing Home DBS[b]	Overall behaviour 67.2 to 58.2 (F=15.6, p<0.001) Significant along Irrational, Uncooperative, Sleep and Inappropriate domains. NS for Annoying and Dangerous domains.	N/A
Psychological wellbeing outcomes						
Mood						
Cohen-Mansfield, 1998	Quasi-crossover (weak)	Nature corridor enhancement	Home corridor enhancement	LMBS[a]	Pleasure subscale I: 1.05 to 1.11 (p<0.05) C: means NR (NS) All other subscales NS for I & C	NR
Reynolds 2018	Quasi-crossover (moderate)	Nature film	Generational movie	OERS subscales: Anxiety[b] Anger[b] Sadness[b] Pleasure[a]	Anxiety: NS effects. I: 1.9 to 1.5 C: 1.5 to 1.4 *p's* not reported	NS interaction (*p*=0.268)

				Alertness[a]	Anger: text states significant decreases of 1.4 to 1.1 (*p*=0.028) in both conditions, but text mismatches Table 1 data (possible typographical error).	NS
					Sadness: NS effects. I: 1.3 to 1.3 C: 1.2 to 1.1 *p's* not reported	NS interaction (p=0.263)
					Pleasure: NS increase in I: 3.7 to 3.5 (p=0.37). Significant decrease in C: 3.8 to 3.3 (p=0.04)	Condition x time interaction effect p=0.027
					Alertness: NS effects. I: 4.9 to 4.9 C 4.9 to 4.9	NS Interaction (p=0.765)
Moyle, 2018	One group pre/post (weak)	Virtual Reality Forest	NA	OERS subscales: Anxiety[b] Anger[b] Sadness[b] Pleasure[a] Alertness[a]	NR	Scores were significantly higher for pleasure (p=0.008) and alertness (p<0.01) but not for sadness

						and anger, when compared to scores previously established for people with dementia in an activity context. 50% of residents showed significantly higher fear
Affect						
Barnicle & Midden, 2003	CCT (moderate)	Horticulture activity programme	Usual care (waiting list)	Affect balance scale[a]	I: 5.42 to 7.61 (F=3.17, p=0.08) C: 4.29 to 3.00 (F=0.70, p=0.40)	I>C for pre to post score change (F=6.78, p=0.01)
Perceived restoration						
Kiyota, 2009	Three-group cluster RCT (weak)	I(1) Indoor plants: active group I(2) Indoor plants: passive group	No plants	Modified PRS[a]	No main effect of time (F=1.553, p=0.169)	No main effect of condition (F=1.094, p=0.359)
						Condition x time interaction (F=2.115, p=0.023). No post hoc tests but appears

						due to late time point improvements in the active I(1) group
Happiness						
Riddick, 1985	Three-group CCT (weak)	Fish aquarium + researcher visits	C(1) Researcher visits only C(2) Control (no aquarium, no researcher visits)	MUNSH[a]	I: -8.14 to -7.86 C(1): -2.00 to -4.38 C(2): -5.14 to -5.86 ($F=0.94$, $p=0.41$)	NR
Yao, 2017	CCT (weak)	Horticulture Therapy programme	Usual care (waiting list)	CHI[a]	I: 11.07 to 14.02 ($t= -5.09$, $p<0.001$) C: 9.84 to 7.98 ($t= 3.27$, $p<0.002$)	I>C for post-test scores (14.15 vs 7.86, $F=59.18$, $p<0.001$). No difference in pre-test scores
Collins, 2008	One-group pre/post (weak)	Horticulture activity programme	N/A	One item for SR happiness on a 1-4 Likert scale[a]	t1 to t2 $t= 2.2$, $p=0.042$ t1 to t3 $t= -2.65$, $p=0.033$ t2 to t3 $t= -2.05$, $p=0.08$	N/A
Loneliness						
Brown, 2004	Cluster RCT (weak)	Indoor gardening programme	20 minute visits from care staff	UCLA Loneliness Scale v3[b]	Group results NR but loneliness in all groups decreased over time ($F=21.31$, $p<0.01$)	NS

Tse, 2010	Cluster RCT (moderate)	Indoor gardening programme	Usual care	Revised UCLA Loneliness Scale (Chinese version)[b]	I: 41.38 to 35.46 (p<0.001) C: 42.56 to 42.44 (p=0.08)	I>C for post-test scores (35.46 vs 42.44, p<0.01). No difference in pre-test scores
Riddick, 1985	Three-group CCT (weak)	Fish aquarium + researcher visits	C(1) Researcher visits only C(2) Control (no aquarium, no researcher visits)	UCLA Loneliness Scale[b]	I: 36.14 to 40.00 C(1): 45.38 to 38.25 C(2): 42:00 to 42.29 (F=2.86, p=0.08)	NR
Mastery						
Collins, 2008	One-group pre/post (weak)	Horticulture activity programme	N/A	Pearlin & Schooler's Mastery Scale[a]	t1 to t2 (*t*= -6.75, p=0.001) t2 to t3 (*t*= -2.0, p=0.086 t1 to t3 (*t*= -4.07, p=0.005)	N/A
Apathy						
Moyle, 2018	One group pre/post (weak)	Virtual Reality Forest	NA	PEAR[b]	t1 18.30 t2 12.10 t3 18.70 t1 to t2 (*p*=0.01) t2 to t3 (*p*=0.005)	N/A
Anxiety						
Scott, 2014	Three-group cluster RCT (moderate)	Biophilia installation	C(1) Reminiscence installation	GAI-SF[b]	No main effect of time I: t1 1.00, t2 1.20, t3 1.90	No main effect of group (F<1.35, p>0.05)

			C(2) No installation		C(1): t1 2.57, t2 1.86, t3 2.00 C(2): t1 2.67, t2 3.16, t3 2.83 (all p>0.05)	
Riddick, 1985	Three-group CCT (weak)	Fish aquarium + researcher visits	C(1) Researcher visits only C(2) Control (no aquarium, no researcher visits)	STAI (Trait A)[b]	Increase in all groups I: 36.71 to 42.43 C(1): 42.13 to 47.75 C(2): 39.43 to 47.43 (F=0.09, p=0.92)	NR
Depression						
Scott, 2014	Three-group cluster RCT (moderate)	Biophilia installation	C(1) Reminiscence installation C(2) No installation	GDS-5[b]	No main effect of time I: t1 1.80, t2 2.00, t3 2.00 C(1): t1 2.38, t2 2.38, t3 2.75 C(2): t1 2.57, t2 2.43, t3 2.42 (all p>0.05)	No main effect of group (F<1.35, p>0.05)
Kiyota, 2009	Three-group cluster RCT (weak)	I(1): Indoor plants: active group I(2): Indoor plants: passive group	No plants	GDS[b]	No main effect of time (F=0.911, p=0.490)	No main effect of group (F=2.09, p=0.156) No condition x time interaction (F=0.749, p=0.700)

Masuya 2014	CCT (weak)	Horticulture activity programme	Usual care	GDS-15[b]	No main effect of time (F=2.92, p>0.05). However, significant improvement occurred in I but not C: I: 5.7 to 3.6 (F=14.01, p<0.05) C: 6.4 to 6.9 (F=0.31, p>0.05)	No main effect of condition (F=1.96, p>0.05) Condition x time interaction (F=8.12, p<0.05)
Social outcomes						
Social Engagement						
Scott, 2014	Three-group cluster RCT (moderate)	Biophilia installation	C(1) Reminiscence installation C(2) No installation	Questionnaire item constructed for the study. Answered on a 1-5 Likert Scale[b]	I: t1 2.85, t2 2.17, t3 2.72 (F=13.82, p<0.001) C(1): t1 2.96, t2 2.42, t3 2.69, (F=3.62, p<0.05) C(2): t1 2.95, t2 2.98, t3 3.20 (F=1.68, p>0.05)	Condition x time interaction (*F*=2.85, p<0.05). Post-hoc tests: I>C(2) at t2 (p<0.001) and t3 (p<0.01) No difference in pre-test (t1) scores I=C(1) at all time points
Brown, 2004	Cluster RCT (weak)	Indoor gardening programme	20 minute visits from care staff	Revised Social Provisions Scale[a]	Group means NR but socialisation	NS

					improved in both groups over time: Enhanced guidance (F=24.84, p<0.01) Reassurance of worth (F=19.33, p<0.01) Social integration F=28.15 p<0.01) Enhanced reliable alliance (F=28.55, p<0.01)	
Tse, 2010	Cluster RCT (moderate)	Indoor gardening programme	Usual care	LSNS[a]	I: 19.27 to 24.77 (p<0.01) C: 18.26 to 18.33 (p=0.16)	I>C for post-test scores (24.77 vs 18.33, p<0.01). No difference in pre-test scores
Interpersonal intimacy						
Yao, 2017	CCT (weak)	Horticulture Therapy programme	Usual care (waiting list)	IIS[a]	I: 44.49 to 48.39 (*t*= -3.28, p=0.002) C:46.30 to 44.57 (*t*= 1.60, p=0.116)	I>C for post-test scores (49.24 vs 43.79, F=16.55, p<0.001). No difference in pre-test scores.
Functional and physical outcomes						
Sleep						

Lee, 2008	One-group pre/post (moderate)	Indoor gardening programme	N/A	24h sleep diaries	Wake after sleep onset [b] 1) Duration: 75.22 to 54.65 mins (*t*= 2.781, p=0.011) 2) Frequency: 6.08 vs 2.21 occasions, *t*= 3.568, p= 0.002) Nap [ǂ] 1) Duration: 158.43 vs 85.87 mins (*t* 7.933, p= <0.001) 2) Frequency: 3.18 vs 1.95 occasions (*t*= 6.480, p=<0.001) Nocturnal Sleep Time[a] 440.48 vs 483.52 mins (*t*= -3.493, p=0.002) Nocturnal sleep efficacy[a] 85.09 vs 89.62% (*t*= -3.048 p=0.006)	N/A

					Changes in sleep onset time, wake up time and total sleep time NS	
Activities of Daily Living (ADL)						
Masuya, 2014	CCT (weak)	Horticultural activity programme	Usual care	ADL-20[a]	No main effect of time (F=1.43, p>0.05) I: 30.0 to 30.8 (F=2.80, p>0.05) C: 41.0 to 40.9 (F=0.13, p>0.05)	No main effect of condition (F=5.36, p>0.05) No condition x time interaction (F=2.54, p>0.05)
Yao, 2017	CCT (weak)	Horticulture Therapy programme	Usual care (waiting list)	BI[a]	I: 62.44 to 67.32 (*t*= -2.04, p=0.048) C: 65.57 to 62.25 (*t*=1.94, p=0.059)	I>C for post-test scores (adjusted means 70.80 vs 58.79, F=11.89, p=0.001) No difference in pre-test scores
Tse, 2010	Cluster RCT (moderate)	Indoor gardening programme	Usual care	MBI[a]	I: 107.19 vs 107.19, (p=1.00) C: 107.11 to 107.11 (p=1.00)	I=C for post-test scores (107.19 vs 107.11, p=0.06) No difference in pre-test scores

Brown, 2004	Cluster RCT (weak)	Indoor gardening programme	20 minute visits from care staff	MDS[a] - Physical Functioning Scale	I: Means NR but significant improvements in Transferring (F=7.87, p<0.01), Eating (F=5.44, p=0.02), Toileting (F=6.28, p=0.01) C: scores NR	NR
Nutrition						
Edwards, 2002	CCT (weak)	Fish aquarium	Scenic ocean picture[c] (waiting list)	Nutritional Intake[a]: weight of food consumed at mealtimes (grams)	I: increased 27.1% from pre to post-test. (*t*= -7.932, p<0.001) C: NS change (*t*= –.882, *p* = .391).	NR
Edwards, 2013	One-group pre/post (weak)	Fish aquarium	N/A	Food Intake[a]: weight of food consumed at mealtimes (grams)	Mean increase of 196.9g (25%, p<0.05) Main effect of phase (F=85.7, p<0.001): the increase between pre-test and the end of the first 2 weeks was greater than between 2 weeks and the end of the study.	N/A
Body weight						

Edwards, 2002	CCT (weak)	Fish aquarium	Scenic ocean picture[c] (waiting list)	Weight[a] (lbs)	I: mean increase of 1.65 lbs (p<0.001) C: NR	NR
Edwards, 2013	One-group pre/post (weak)	Fish aquarium	N/A	Weight[a] (lbs)	158.4 to 160.6 (*t*=7.5, p=0.000 <0.05/3)	N/A
Physiological Outcomes						
Reynolds 2018	Quasi-crossover (moderate)	Nature film	Generational movie	Heart rate[b] (pulse oximetry)	I: 78.3 to 69.8 (p=0.03) C: 75.0 to 74.6 (p=0.72)	Condition x time interaction (p=0.012)
DeSchriver, 1990	RCT (weak)	Fish aquarium	C(1) Fish videos[c] C(2) Videos of static	1) Pulse rate[b] (brachial artery monitor) 2) Skin temperaturea (finger thermometer) 3) Muscle tension [b] (bicep EMG)	No significant within-group changes in any measure from pre to post-test observed for any group.	No significant differences in post-test scores between the three groups in any measure, controlled for pre-test scores.
Riddick, 1985	Three-group CCT (weak)	Fish aquarium + researcher visits	C(1) Researcher visits only C(2) Control (no aquarium, no researcher visits)	Blood pressure[b] (Sphygmomanometry)	Diastolic BP I: 82.00 to 74.57 (*t*=2.60, p=0.04) C1: 72.25 to 69.50 (*t*=0.96, p=0.37) C2: 78.86 to 76.00 (*t*=0.46, p=0.66)	NR

					Systolic BP NS changes for any group (F=0.31, p=0.74)	
Goto, 2014	CCT (weak)	Indoor Japanese garden	C(1) Snoezelen room C(2) Participant's bedroom	Pulse rate[b] (finger plethysmography)	I: consistent decline of 0.15-0.2 bpm throughout sessions C1: variable but average increase of 0.06 bpm throughout sessions. No stats performed.	I>C2 for the final 6 min of recording (p=0.034) C1=C2 for the final 6 min of recording (p=0.34). No direct I to C1 comparison
	General health, wellbeing and satisfaction outcomes					
Engagement						
Powell, 1979	CCT (weak)	Gardening days (optional indoor gardening session)	Non-gardening days	Constructed for study: is participant engaged? yes/no Converted to % engaged as a proportion of total sample.	I: engagement ranged from 34-51% across sessions C: engagement ranged from 20-41% across sessions No within-group stats performed but levels varied for both conditions	I>C engagement level averaged 43% on gardening days and 31% on non-gardening days (p<0.005)

Aslakson, 2010	RCT (weak)	Nature videos	Music therapy	Tool constructed for study[a]	I: 3.4 to 2.3, effect size 0.59 (moderate). C: 3.3 to 4.5, effect size 0.94 (high)	I<C for pre to post-score change (F=24.54, p<0.01) Effect size between I & C: η^2=0.392
Eggert, 2015	Within-subjects quasi-experiment (weak)	Preferred nature images (photographs)	Preferred music	IDEAS[a]	I & C: slight score improvements between 0.7 and 1.8 from pre to post-session every week. No stats performed.	NR
Moyle, 2018	One group pre/post (weak)	Virtual Reality Forest	NA	Duration spent engaged in the activity[a] coded as: • No engagement: the participant is not engaging in the activity • Self-engagement: participant is engaging without encouragement • Facilitated engagement: participant is engaging with encouragement from staff	Total time engaged with the Virtual Reality Forest ranged from 8.03 to 12.30 min, with an average of 10.22 min (*SD* = 1.07). There were no significant differences in durations spent in each type of engagement: Not engaged: 4.45 min (*SD* = 2.4) Facilitated: 3.33 min (*SD* = 1.57)	NA

					Self-engaged: 2.44 min (*SD* = 2.11)	
Perceived health						
Collins, 2008	One-group pre/post (weak)	Horticulture activity programme	N/A	SR health[a]	t1 to t2 (*t*= -4.12, p=0.001) t2 to t3 (*t*= -0.75, p=0.02) t1 to t3 (*t*= -3.99, p=0.005)	N/A
Perceived wellbeing						
Kieffer, 2014	Cross-sectional (weak)	Representational elements of nature (photographs)	N/A	Questionnaire constructed for the study containing five items relating to perceived wellbeing[a] 1) Refreshed-exhausted 2) Distracted – attentive 3) Relaxed – harried 4) Irritable – patient 5) Comfortable – uneasy	Images containing water perceived as better for wellbeing than images without water on all 5 scales. Images containing natural materials perceived as worse for wellbeing than pictures without natural materials on 4/5 scales. Results for images containing fire and botanical motifs were mixed. No stats.	N/A
Quality of Life						

Masuya, 2014	CCT (weak)	Horticultural activity programme	Usual care	VAS[a]	Satisfaction with life I: 75.6 to 91.1 (F=28.00, p<0.05) C: 78.8 to 81.1 (F=2.29, p>0.05)	Satisfaction with life Condition x time interaction (F=16.46, p<0.05)
					No significant changes for either group in any of the other 6 subscales	NS differences in the other 6 subscales
Meaning of Life						
Yao, 2017	CCT (weak)	Horticulture Therapy programme	Usual care (waiting list)	MLS[a]	I: 74.49 to 76.61 (t= -3.25, p=0.002) C: 73.89 to 76.07 (t= -2.07, p=0.045)	I=C for adjusted post-test scores (76.47 vs 76.19, F=0.11, p=0.738) No difference in pre-test sores
Life satisfaction						
Tse, 2010	Cluster RCT (moderate)	Indoor gardening programme	Usual care	LSI-A[a] (Chinese version)	I: 11.73 to 15.73 (p<0.01) C: 11.56 to 11.67 (p=0.08)	I>C for post-test scores (15.73 vs 11.67, p<0.01). No difference in pre-test scores
Satisfaction with opportunities to keep occupied						

Scott, 2014	Three-group cluster RCT (moderate)	Biophilia installation	3) Reminiscence installation 4) No installation	Questionnaire constructed for the study: answers on 1-5 Likert Scales[a]	No main effect of time I: t1 2.10, t2 1.90, t3 2.20 C(1): t1 2.38, t2 2.38, t3 2.75 C(2): t1 2.57, t2 2.43, t3 2.42 (all p>0.05)	No main effect of condition (F<1.35, p>0.05)
Leisure satisfaction						
Riddick, 1985	Three-group CCT (weak)	Fish aquarium + researcher visits	1) Researcher visits only 2) Control (no aquarium, no researcher visits)	LSS[a]	I: 63.57 to 74.00 C(1): 68.50 to 74.50 C(2): 67.00 to 65.29 (F=1.35, p=0.28)	NR
Satisfaction with living environment						
Scott, 2014	Three-group cluster RCT (moderate)	Biophilia installation	1) Reminiscence installation 2) No installation	Questionnaire constructed for the study: answers on 1-5 Likert Scales[a]	No main effect of time I: t1 2.30, t2 1.70, t3 2.20 C(1): t1 2.13, t2 2.13, t3 2.13 C(2): t1 2.14, t2 2.14, t3 2.29 (all p>0.05)	No main effect of condition (F<1.35, p>0.05)

Appendix 4. Detailed study outcomes. Scores reported as group means unless otherwise stated. C control/comparator; I intervention; N/A not applicable; NR not reported; NS not significant (no means provided); t1 baseline/pre-test scores; t2 mid-intervention or post-test scores; t3 post-test or follow-up scores; [a]increasing scores = improvement in outcome; [b]decreasing scores = improvement in outcome; [c]condition was a control group in the individual study but is considered as an intervention in the current

review. Colour coding: in the within-groups column, green indicates the intervention group (but not the control/comparator group, if applicable) was significantly effective over time; yellow indicates the intervention group had no significant effect over time; red indicates the control/comparator group (but not the intervention group) was significantly effective over time. In the between-groups column, green indicates a significant difference favouring intervention; yellow indicates no between-group differences; red indicates a significant difference favouring control/comparator. In either column, no colour indicates results were inconsistent/mixed, or direction of effect(s) were unclear, or some results were not reported, or the study only reported descriptive statistics, or the test was not performed or not applicable.
ADL Activities of Daily Living; BAC Behavioural Assessment Checklist; BARS Brief Agitation Ratings Scale; BI Barthel Index; CCT controlled clinical trial; CHI Chinese Happiness Inventory; CMAI Cohen-Mansfield Agitation Inventory; DBS Disruptive Behaviour Scale; FBP Functional Behaviour Profile; GAI-SF Geriatric Anxiety Inventory short form; GDS Geriatric Depression Scale; GDS-5 Geriatric Depression Scale short form; HDRS-R Hasegawa Dementia Rating Scale – Revised; IDEAS Individualized Dementia Engagement and Activities Scale; IIS Interpersonal Intimacy Scale; LMBS Lawton's Modified Behaviour Stream; LSI-A Life Satisfaction Index-A; LSNS Lubben Social Network Scale; LSS Leisure Satisfaction Scale; MoCA Montreal Cognitive Assessment; MBI Modified Barthel Index; MDS Minimum Data Set; MDS+ Minimum Data Set Plus; MLS Meaning of Life Scale; MMSE Mini Mental State Exam; MUNSH Memorial University of Newfoundland Scale of Happiness; N/A not applicable; OERS Observed Emotions Ratings Scale; PEAR Person Environment Apathy Rating; PRS Perceived Restoration Scale; QoL Quality of Life; RCT randomised controlled trial; RSS Residential Satisfaction Scale; SR self-reported; STAI State-Trait Anxiety Inventory; TSI Test for Severe Impairment; VAS Visual Analogue Scale; WAI Wisconsin Agitation Inventory.

PRISMA checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1-2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3 and Table 1
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3-4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4 and Table 1
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4 and Appendix 2

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Appendix 2
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	17-18
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6, Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table 2, Appendix 3
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 3 and within narrative synthesis p7-13
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	(a) Table 2, Appendix 4. (b) explanation of why this was not possible on p5

Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Presented within narrative synthesis p7-13
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13-15, 19-20
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	17-18
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	18-19
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	21