Preventive Medicine Reports 5 (2017) 92–99

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: http://ees.elsevier.com/pmedr

Review Article

Gardening is beneficial for health: A meta-analysis

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ARTICLE INFO

Article history:
Received 22 June 2016
Received in revised form 10 October 2016
Accepted 6 November 2016
Available online 14 November 2016

Keywords:
Ecosystem services
Domestic gardens
Green exercise
Green infrastructure
Horticulture
Nature experiences
Preventive healthcare
Public health
Urban greenspace
Wellbeing

ABSTRACT

There is increasing evidence that gardening provides substantial human health benefits. However, no formal statistical assessment has been conducted to test this assertion. Here, we present the results of a meta-analysis of research examining the effects of gardening, including horticultural therapy, on health. We performed a literature search to collect studies that compared health outcomes in control (before participating in gardening or non-gardeners) and treatment groups (after participating in gardening or gardeners) in January 2016. The mean difference in health outcomes between the two groups was calculated for each study, and then the weighted effect size determined both across all and sets of subgroup studies. Twenty-two case studies (published after 2001) were included in the meta-analysis, which comprised 76 comparisons between control and treatment groups. Most studies came from the United States, followed by Europe, Asia, and the Middle East. Studies reported a wide range of health outcomes, such as reductions in depression, anxiety, and body mass index, as well as increases in life satisfaction, quality of life, and sense of community. Meta-analytic estimates showed a significant positive effect of gardening on the health outcomes both for all and sets of subgroup studies, whilst effect sizes differed among eight subgroups. Although Egger's test indicated the presence of publication bias, significant positive effects of gardening remained after adjusting for this using trim and fill analysis. This study has provided robust evidence for the positive effects of gardening on health. A regular dose of gardening can improve public health.

Contents

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http://dx.doi.org/10.1016/j.pmedr.2016.11.007

1. Introduction

Globally, the prevalence of the so-called "lifestyle diseases," such as heart disease, stroke, depression, diabetes, and obesity is becoming a major public health issue (Caballero, 2007; Janssen et al., 2005; Moussavi et al., 2007). It is, for example, estimated that worldwide, approximately 415 and 350 million people presently suffer from diabetes and depression, respectively, and hence both are costly to national health care budgets (IDF, 2015; WHO, 2016). Unfortunately, this trend is expected to continue for the foreseeable future as a high number and proportion of the world's population will be living in urban areas (Seto et al., 2012). Indeed, urban living is associated with various adverse health consequences, such as high-fat diets, sedentary lifestyles, and increased levels of social and psychological stress and environmental pollutants (Clougherty et al., 2007; Lambert et al., 2015; Peer et al., 2003; Sodjinou et al., 2008). As a consequence, promoting health of urban populations has become one of the most challenging issues of the 21st century (Dye, 2008; Tzoulas et al., 2007).

Nature in cities can play a key role in achieving a healthy society (Groenewegen et al., 2006; Tzoulas et al., 2007). Indeed, there is mounting evidence that direct experience with natural environments offers a wide range of health benefits (Hartig et al., 2014; Keniger et al., 2013; Soga and Gaston, 2016). Louv (2005) argued that a decrease in contact with nature results in a number of health and behavioural problems, especially children, which in sum can constitute a "nature-deficit disorder." Recent studies suggest that daily contact with nature has a long-lasting and deep impact on health, including on depression and anxiety symptoms (Beyer et al., 2014), birth weight (Dadvand et al., 2012), diabetes, and obesity (Lachowycz and Jones, 2011), circulatory and heart disease (Maas et al., 2009), and longevity (Takano et al., 2002). It is therefore increasingly recognized that a regular contact with nature can promote human health and be used as a form of preventive medicine (Groenewegen et al., 2006).

Gardening is arguably one of the most common ways of interacting with nature and indeed is enjoyed as a popular pastime in many countries. In the UK, there are estimated to be 27 million people, approximately 40% of the total population, who actively participate in gardening (Bisgrove and Hadley, 2002). Likewise, it is estimated that in the US, 117 million people, one in three, participate in gardening (Statista, 2015), and that in Japan, 32 million people, one in four, participate in daily gardening as a hobby (Statistics Bureau, Ministry of Internal Affairs and Communications, 2011). Gardening requires, at most, a relatively small piece of land, and in many parts of the world, such gardens are today common. In the UK, it is estimated that 22.7 million households (87%) have access to a domestic garden, which comprise 432,924 ha of land in total (Davies et al., 2009). Mathieu et al. (2007) also showed that more than a third of the land in the city of Dunedin, New Zealand, was used for domestic gardens. Alongside domestic gardens, allotment and community gardens, pieces of land with plots rented by an individual or group to grow plants for non-commercial use also offer places in which people can participate in gardening. The city of Stockholm, Sweden, for example, contains approximately 10,000 allotment plots, which occupy 210 ha of land and involve 24,000 people (c.f. Barthel et al., 2010). Given the scale of gardening activities, and the apparent feasibility of accommodating them in cities and towns, these have great potential for limiting the ongoing loss of human–nature interaction—the extinction of experience (Soga and Gaston, 2016; Soga et al., 2016).

There is increasing awareness among researchers and health practitioners of the potential health benefits derived from gardening activities (Clatworthy et al., 2013; Genter et al., 2015; Wang and MacMillan, 2013). Indeed, previous studies have shown that gardening increases individual's life satisfaction, vigor, psychological wellbeing, positive affects, sense of community, and cognitive function (Gigliotti and Jarrott, 2005; Gonzalez et al., 2010; van den Berg et al., 2010; Wakefield et al., 2007; Wichrowski et al., 2005; Wood et al., 2016). Reductions in stress, anger, fatigue, and depression and anxiety symptoms have also been documented (Rodiek, 2002; Wichrowski et al., 2005; Wilson and Christensen, 2011; Wood et al., 2016). In consequence, engagement with gardening has increasingly been recognized as not only a cost-effective health intervention (Clatworthy et al., 2013) but also a treatment or occupational therapy for those with psychological health issues, so-called "horticultural therapy" (Gonzalez et al., 2010, 2011a). Despite this, surprisingly, to date no meta-analysis has been conducted to assess the consistency of the positive effects of gardening on health. There have recently been two systematic reviews of studies exploring the association between gardening and health (Genter et al., 2015; Wang and MacMillan, 2013). However, since they presented no quantitative synthesis and only focused on health benefits of allotment gardening (Wang and MacMillan, 2013) and for elderly people (Genter et al., 2015), respectively, more comprehensive and convincing evidence is still wanting. Here, we present a formal meta-analysis of research examining the effects of gardening on health.

2. Materials and methods

2.1. Terminology

As defined by the WHO (1948), health is "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity," we interpret "health" in a broad sense to include physical and psychological wellbeing. Positive effects on health are thus not simply the amelioration of symptoms associated with chronic illness (e.g. depression, anxiety, obesity) but include the presence of positive emotions (e.g. quality of life, life satisfaction, sense of community, happiness) and the absence of negative emotions (e.g. anger, loneliness, confusion), and the state of being able to perform the normal actions of daily life without the hindrance of both physical and psychological dysfunction. Increased physical activity level was also included as a positive health outcome, as it has proven to be a [illegible] indicator of risk for obesity-related diseases (Janssen et al., 2005). We use the term "gardening" for "an activity in which people grow, cultivate, and take care of plants (flowers and vegetables) for non-commercial use," which is not simply limited to an activity in domestic gardens but includes that in allotment and community gardens. In this study, horticultural therapy, a practice of engaging patients in gardening activities to improve their physical, psychological, and social health, was also considered as a form of gardening.

2.2. Systematic review and inclusion criteria

We focused on studies that collected data on people's health outcomes in the context of gardening, were published in peer-reviewed scientific journals after 2001, and were written in English. This study followed the PRISMA statement (Moher et al., 2009). We performed the search, assessed eligibility, and extracted data. Literature search was conducted using the PubMed database [illegible] January 2016. We used the following terms in the keyword search: *Physical activity* OR *Health* OR *Restoration* OR *Recovery* OR *Therapy* OR *Well-being* OR *Wellbeing* OR *Well being* OR *Psychology* OR *Quality of life* OR *Life satisfaction* OR *Happiness* OR *Anxiety* OR *Depression* OR *Stress* OR *mood* OR *Pain* OR *Obesity* OR *Social* AND *Gardening* OR *Allotment* OR *Allotment gardening* OR *Horticulture* OR *Horticultural therapy* OR *Community Garden*. The PubMed search resulted in 2456 records. We also ran similar queries on Google Scholar in January 2016 to identify studies that had previously been missed. We searched using all possible combinations of the above 19 health terms and 6 gardening terms (114 combinations), and examined the first 50 hits from each (5700 records in total). Studies identified through PubMed and Google Scholar were screened on title, abstract, or both, and 79 full-articles were assessed for eligibility. The eligible articles were obtained from the Internet, via the University of Tokyo electronic library, or by personal contact with the authors. To be included in

In meta-analysis, a study had to (1) conduct a quantitative survey rather than a qualitative one, (2) focus on outdoor gardening, (3) have control (before participating in gardening or non-gardeners) and treatment groups (after participating in gardening or gardeners), (4) report sample size and mean and standard deviation (SD) or error (SE) of health outcomes both for the control and treatment groups, and (5) have >11 participants (sample size). Reviews of previous work and study protocols were ignored.

2.3. Data extraction

We finally included 21 articles [22 case studies; one paper (Gonzalez et al., 2011a) reported two independent studies] in the meta-analysis (see Table 1). The study selection process (PRISMA diagram) is shown in Fig. 1. Basic information was collected for these studies, including the first author's name, year and name of publication, country of origin, and details of settings (duration and types of gardening), participants (mean age, female ratio, and health condition), and types of health outcomes measured. We also extracted mean values of health outcomes, sample size (n), and SD for both the control and treatment groups. If a single study reported data on more than one health outcome, then we considered each comparison between the control and treatment groups (hereafter comparison) independently. Duplicate results that were derived from repeated analyses (e.g. subgroup analysis) were ignored. For studies that measured health outcomes during gardening on multiple occasions, we used only data points at the start (control) and end (treatment). One study (Park et al., 2009) compared health outcomes of people with multiple levels of gardening activity (non-gardeners, gardeners, and active gardeners; here, active gardeners were defined as those who met or exceeded recommended physical activity levels by gardening, and gardeners as those who did not meet this recommendation by gardening but did garden as moderate intensity). In this case, we compared only non-gardeners and gardeners. We finally obtained 76 comparisons. The full dataset is listed in Table S1.

2.4. Statistical analysis

We performed the meta-analysis using the "metafor" package (Viechtbauer, 2010) in R (ver. 3.2.2) (R Core Team, 2015). The standardized mean difference Hedges' d (Hedges and Olkin, 1985) was used as the effect size metric for comparing mean differences in health outcomes between the treatment and control groups:

$$d = (M_t - M_c)J/S$$

where M_t and M_c are the mean values of the response variable (health outcomes) in the treatment and control groups, respectively, and S and J are the pooled SD of both groups and a term that corrects for bias due to small sample size, respectively. Here, positive effect sizes indicate that health condition is better in the treatment groups than in the control groups; we reversed the sign of health outcomes where higher values meant a less healthy condition (e.g. depression, anxiety, stress).

Based on the effect size of each comparison, we calculated the overall pooled effect size and its 95% confidence interval (CI) as a weighted average of all 22 case studies (76 comparisons). Significance of the overall effect size was assessed by determining whether the CI overlapped zero. Since preliminary analysis showed significant between-study heterogeneity (see the Results section), we used a weighted random-

Table 1
Characteristics of 22 case studies.

Study	Country	Participants	% Female	Mean age	Gardening type	Health outcome
Ghanbari et al. (2015)	Iran	50 female students with depression	100.0	20.6	Horticultural therapy	Depression
Gigliotti and Jarrott (2005)	USA	48 people with dementia	45.8	80.0	Horticultural therapy	Positive affect
Gigliotti et al. (2004)	USA	14 people with dementia	–	83.0	Horticultural therapy	Positive affect
Gonzalez et al. (2010)	Norway	28 people with depression	75.0	44.1	Horticultural therapy	Depression, attention (cognitive function), brooding (rumination), and being away and fascination (restorativeness)
Gonzalez et al. (2011a)	Norway	18 people with depression	83.3	49.7	Horticultural therapy	Depression and existential issues
Gonzalez et al. (2011a)	Norway	28 people with depression	75.0	44.1	Horticultural therapy	Depression and existential issues
Gonzalez et al. (2011b)	Norway	46 people with depression	78.3	46.3	Horticultural therapy	Depression, anxiety, positive affect, and stress
Hayashi et al. (2008)	Japan	61 people	63.9	46	Experimental short-term gardening	Mood, tension, depression, anger, vigor, fatigue, and confusion
Kam and Siu (2010)	China	24 people with psychological illness	29.2	44.3	Horticultural therapy	Depression, anxiety, stress, and quality of life
Kim et al. (2012)	South Korea	24 students with intellectual disabilities	58.3	8.5	Horticultural therapy	Attention (cognitive function) and sociability
Kotozaki (2014)	Japan	45 women	100.0	46.5	Horticultural therapy	Sense of community, self-esteem, general health, and depression
Min et al. (2014)	South Korea	45 women	100.0	–	Horticultural therapy	Psychological wellbeing and hope
Park et al. (2009)	USA	53 people	64.2	71.9	Daily gardening	Bone mineral density
Rodiek (2002)	USA	17 women	100.0	84.7	Experimental short-term gardening	Anxiety, mood, and salivary cortisol (stress)
Sommerfeld et al. (2010)	USA	261 people	59.8	over 50	Daily gardening	Life satisfaction, physical activity levels, and general health
van den Berg and Custers (2011)	Netherlands	30 people	73.3	57.6	Experimental short-term gardening	Mood and salivary cortisol (stress)
van den Berg et al. (2010)	Netherlands	184 people	51.1	59.6	Daily gardening	General health, physical constraints, health complaints, chronic illnesses, frequency of consulting in general practice, stress, life satisfaction, loneliness, social contacts, physical activity levels
Waliczek et al. (2005)	USA	443 people	72.8	–	Daily gardening	Life satisfaction
Wichrowski et al. (2005)	USA	107 cardiac rehabilitation inpatients	39.3	–	Horticultural therapy	Mood, tension, depression, anger, vigor, fatigue, confusion, and heart rate (stress)
Wilson and Christensen (2011)	USA	269 people with disabilities	62.1	55	Daily gardening	Depression
Wood et al. (2016)	UK	269 people	43.5	55.6	Daily gardening	Self-esteem, general health, tension, depression, anger, vigor, fatigue, confusion, mood, and body mass index
Zick et al. (2013)	USA	514 people	49.8	43.9	Daily gardening	Body mass index

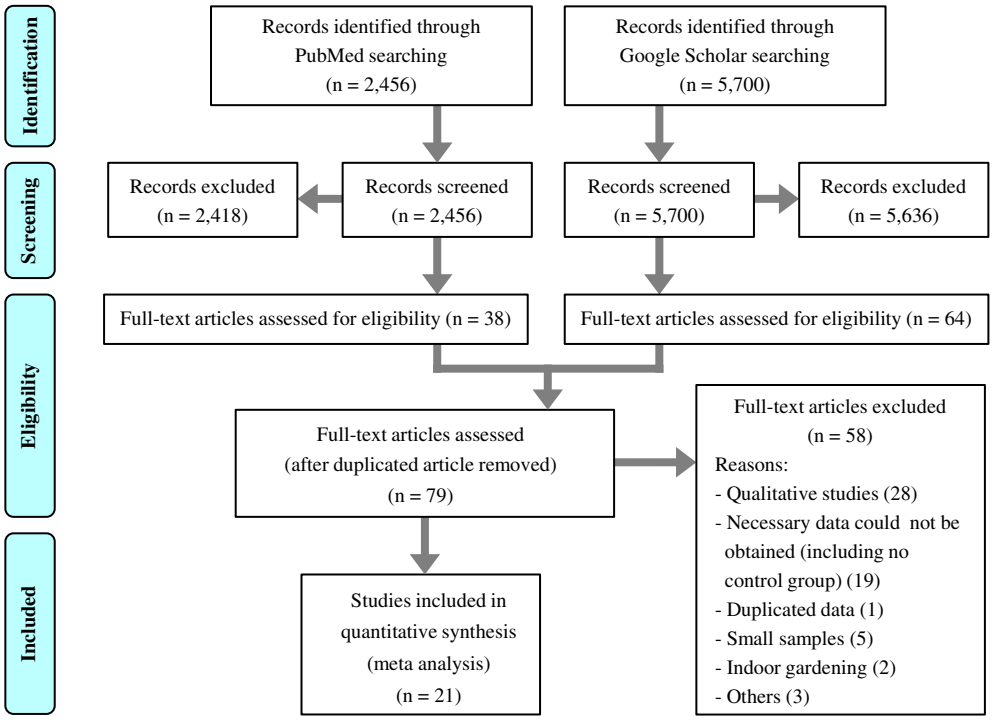

Fig. 1. Flow diagram of literature search and study selection process.

effects model to estimate the overall effect size and CI. The random-effects model assumes that different studies are not exactly identical in the survey methodologies and the characteristics of respondents. Heterogeneity between studies was checked by the Q test and I^2 statistic. In order to account for the possibility of pseudoreplication derived from using multiple comparisons from within studies, we recalculated the overall effect sizes after sampling one comparison from each separate study. The estimated mean and 95% CI of effect size were computed by bootstrap resampling 10,000 times in R.

11 Aaron Godlaski As well as for the overall studies ($n = 76$ comparisons), a meta-analysis was performed for different groups of studies (hereafter subgroups) to examine whether the impacts of gardening on health differed. We split the 76 comparisons into two subgroups based on the types of health outcomes (health variables: $n = 18$; wellbeing variables: $n = 58$), gardening (therapy: $n = 33$; non-therapy: $n = 43$), comparisons (before/after gardening: $n = 32$; gardeners/non-gardeners: $n = 44$), and respondents (patients: $n = 28$; non-patients: $n = 48$). In this study, "wellbeing" was interpreted simply as "the state of being comfortable, happy, or prosperous"; proposing a single definition of wellbeing is still a substantial general challenge (Dodge et al., 2012). This includes the presence of positive emotions (e.g. happiness, vigor, hope), the absence of negative emotions (e.g. loneliness, anger, confusion), and satisfaction and fulfillment of life. Statistical difference in the mean effect size between two subgroups in each category was evaluated with Cochran's Q test implemented in the "metafor" package in R.

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2.5. Publication bias

13-14 2 notes:

The possibility of publication bias (a lower likelihood of studies being published that reported non-significant results than reported significant ones) was assessed using a funnel plot and Egger's test (Egger et al., 1997; Nakagawa and Santos, 2012). If publication bias was indicated by Egger's test, we performed a trim and fill analysis (with the R0 estimator) (Duval and Tweedie, 2000). This estimates the number of missing studies (comparisons) in the original dataset and provides a true effect size: that is, an effect size when publication bias is not present.

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The trim and fill analysis was performed using the "trimfill" functions of the "metafor" package in R.

3. Results

3.1. Descriptive results

An overview of the 22 case studies is presented in Table 1. The sample sizes ranged from 14 to 514 people (M = 117.2, SD = 144.5). Many of the studies came from the United States (9 studies), followed by Europe (7 studies), Asia (5 studies), and the Middle East (1 study). The participants ranged in average age from 8.5 to 84.7 years (M = 52.3, SD = 19.6), with the percentage of females ranging from 29.2 to 100.0% (M = 67.8, SD = 21.0). Eleven studies focused on patients (e.g. dementia, depression) and 11 on non-patients. Gardening types included horticultural therapy (12 studies), daily gardening (7 studies), and experimental short-term gardening (3 studies). Studies used a wide range of health outcomes (Table 1).

3.2. Meta-analysis results

The results of the comparisons and the meta-analytic estimates are shown in Fig. 2. Most studies reported positive effects of gardening, and none reported significant negative effects (Fig. 2). The 95% CI of the overall pooled effect size did not overlap zero (mean = 0.42, 95% CI: 0.36–0.48), suggesting a significant effect of gardening on the health outcomes (Fig. 2). We found significant between-study heterogeneity in the overall analysis ($I^2 = 40.47\%$, $Q_{75} = 137.38$, $P < 0.001$). After repeated resampling using bootstrap simulation, the overall effect sizes remained significantly positive (mean = 0.47, 95% CI: 0.36–0.57) and its 95% CIs largely overlapped with those in the primary analysis (Fig. S1). Thus, the reported results overall would not be biased by pseudoreplication.

The 95% CI of effect size did not overlap zero for all eight subgroups (Table 2). The effect size of gardening on the health outcomes differed significantly between two subgroups for all four categories (outcome types: $Q_1 = 6.48$, $P = 0.01$; gardening types: $Q_1 = 24.71$, $P < 0.001$;

comparison types: $Q_1 = 18.31$, $P < 0.001$; respondent types: $Q_1 = 17.96$, $P < 0.001$) (Table 2). Studies focused on wellbeing variables, horticultural therapy, before/after comparison method, and patients showed higher effect sizes of gardening, compared to the other subgroups (Table 2). Of the eight subgroups, between-study heterogeneity was found for five (Table 2).

3.3. Publication bias

Egger's test indicated the presence of publication bias ($t = 4.18$, d.f. $= 64$, $P < 0.001$). The trim and fill analysis suggested that 16 studies (comparisons) were missing from our dataset (white circles in Fig. 3). However, after adding those missing data to the original dataset, reported significant effects of gardening on the health outcomes were intact (mean = 0.35; 95% CI: 0.27–0.43, Fig. 3), suggesting that the effects of publication bias on the overall results were negligible.

4. Discussion

To our knowledge, this meta-analysis is the first to provide a quantitative synthesis of the evidence that gardening is beneficial for human health. Overall, the results suggest that participating in gardening activities has a significant positive impact on health. Indeed, the positive association with gardening was observed for a wide range of health outcomes, such as reductions in depression and anxiety symptoms, stress, mood disturbance, and BMI, as well as increases in quality of

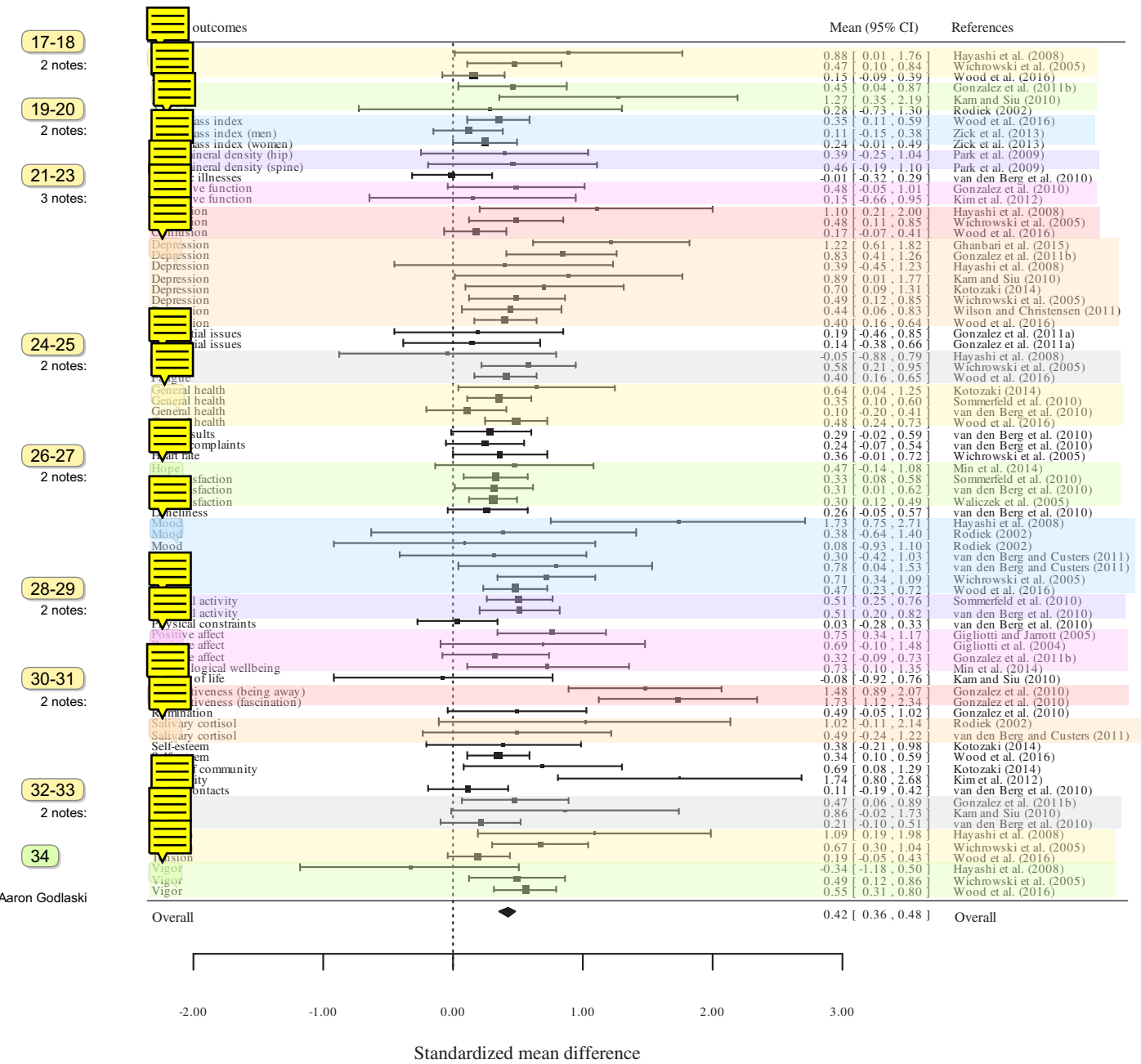

Fig. 2. Standardized mean differences in the health outcomes between the control and treatment groups for 76 comparisons. Positive values indicate improved health outcomes. Dotted and solid lines indicate the effect size of 0 and 95% CI, respectively. Positive affect means the extent to which one is experiencing positive mood states, such as joy, cheerfulness, and enthusiasm.

life, sense of community, physical activity levels, and cognitive function. The 22 case studies were geographically dispersed, although more than one-third came from the United States. Publication bias is a common limitation of meta-analysis (Nakagawa and Santos, 2012). Nevertheless, our results remained quantitatively almost unchanged after using the trim and fill analysis, suggesting that the reported health benefits of gardening are robust. Given the recent rise in awareness of the health benefits derived from nature (Hartig et al., 2014; Keniger et al., 2013), these findings are particularly timely and support the argument that a regular dose of gardening can improve health.

Studies included in our analysis varied substantially with respect to the demographic characteristics of the participants and settings, which is likely to be the main reason for significant between-study heterogeneity. To account for this issue, we performed subgroup analysis and determined that significant positive effects of gardening on health existed for all subgroups. Positive influences of gardening were particularly evident on patients and horticultural therapy users. This is unsurprising because these groups would explicitly use, and be exposed to, gardens in a more health-supportive way than would non-patients. Likewise, studies using a "before and after" comparison method, which were commonly seen in horticultural therapy studies (Ghanbari et al., 2015; Gonzalez et al., 2010, 2011a, 2011b; Kotozaki, 2014; Min et al., 2014; Wichrowski et al., 2005), reported a larger effect size of gardening than those simply comparing a treatment (gardeners) to a control group (non-gardeners). Our subgroup analysis also indicated that wellbeing variables are more likely enhanced sharply by gardening than health variables. Although it is difficult to provide a precise explanation due to the limited sample size, one possible reason for this result is that the improvement of health variables would need a relatively longer time, compared to wellbeing. As wellbeing variables were in many cases measured on a subjective scale (e.g. depression, anxiety, quality of life, life satisfaction) (Ghanbari et al., 2015; Kam and Siu, 2010; Kotozaki, 2014; van den Berg et al., 2010; Waliczek et al., 2005; Wood et al., 2016), they were more likely to respond immediately than objective health outcomes (e.g. BMI) (Park et al., 2009; van den Berg et al., 2010; Wood et al., 2016; Zick et al., 2013).

There was substantial variation among the 22 case studies in the duration and frequency of the gardening treatment, and each study has its particular implications. Three studies assessed respondents shortly before and after experimental short-term gardening activities (Hayashi et al., 2008; Rodiek, 2002; van den Berg and Custers, 2011). These studies showed that even short-time (several hours) exercise in gardens can provide an instantaneous beneficial influence on health (e.g. reductions in depression and anxiety symptoms), although it is unknown how long the positive outcomes last after gardening. Twelve studies focused on horticultural therapy and investigated changes in people's health states over several weeks or months (Ghanbari et al., 2015; Gigliotti and Jarrott, 2005; Gigliotti et al., 2004; Gonzalez et al., 2010, 2011a, 2011b; Kam and Siu, 2010; Kim et al., 2012; Kotozaki, 2014; Min et al., 2014; Wichrowski et al., 2005). Notably, Gonzalez et al. (2010, 2011a, 2011b) observed that improvement of patients' health status (e.g. depression severity, life satisfaction, cognitive function) persisted at 3-months' follow up after the therapy, indicating that gardening has a persisting influence on health. Of the 22 case studies, 7 studies focused on daily gardening and found that those who participated had better health than did non-gardeners, such as reductions in stress and BMI, as well as increases in general health and life satisfaction (Park et al., 2009; Sommerfeld et al., 2010; van den Berg et al., 2010; Waliczek et al., 2005; Wilson and Christensen, 2011; Wood et al., 2016; Zick et al., 2013). The strength of these studies is that they found no significant difference in the characteristics or socio-economic status of gardeners and non-gardeners, or controlled for these factors. Also, these studies indicate that repeated short-term exercise in gardens has a cumulative effect on health. Given the evidence presented above, it is obvious that gardening has both immediate and long-term effects on health, and an important direction for future research is to determine the shape of relationships between the dose (duration and frequency) of gardening exercise and health outcomes.

Although our meta-analysis presents a consistent result, untangling the causal relationships between gardening and improved health outcomes is not an easy task. There are several possible, but not mutually exclusive, pathways through which gardening promotes health. The first, and most direct one, is the added health benefits of direct exposure with nature (Hartig et al., 2014; Keniger et al., 2013). Indeed, attention restoration theory proposes that the natural world is cognitively restorative and exposure to nature has the potential to allow restoration from attentional fatigue (Kaplan, 1995). Second, and somewhat more indirectly, gardening is likely to encourage people to undertake physical exercise, which in turn would contribute to improving both the physical and psychological health of gardeners (Park et al., 2009; van den Berg et al., 2010; Zick et al., 2013). Notably, in the US, Park et al. (2008) pointed out that if elderly people participated in daily gardening, they could achieve recommended physical activity levels (at least 30 min of moderate intensity physical activity on most, preferably all, days). Third, gardens, especially allotment and community gardens, provide opportunities to interact with other members of local communities, which is likely to forge and reinforce social ties, community networks, and sense of community (van den Berg et al., 2010; Wakefield et al., 2007). Fourth, and most indirectly, engagement in gardening could ensure people have a healthier diet, rich in fruits and vegetables (Langellotto and Gupta, 2012). Given these widespread benefits coming from gardening, we should consider gardens as an important and promising health resource for the local community.

Table 2
Summary of the meta-analysis for eight subgroups.

Subgroups	No. of comparison	Effect size			Heterogeneity	Between-subgroup difference
		Mean	SE	995% CI		
Outcome types						
Health variables	18	0.31	0.05	0.21–0.40	$Q_{17} = 28.93, P = 0.04$	$Q_1 = 6.48, P = 0.01$
Wellbeing variables	58	0.47	0.04	0.39–0.54	$Q_{57} = 102.53, P < 0.001$	
Gardening types						
Therapy	33	0.61	0.05	0.51–0.72	$Q_{32} = 51.76, P = 0.02$	$Q_1 = 24.71, P < 0.001$
Non-therapy	43	0.31	0.03	0.26–0.37	$Q_{42} = 53.85, P = 0.10$	
Comparison types						
Before/after gardening	32	0.60	0.06	0.49–0.71	$Q_{31} = 54.03, P = 0.006$	$Q_1 = 18.31, P < 0.001$
Gardeners/non-gardeners	44	0.32	0.03	0.27–0.38	$Q_{43} = 57.51, P = 0.07$	
Participant types						
Patients	28	0.61	0.06	0.49–0.74	$Q_{27} = 51.30, P = 0.003$	$Q_1 = 17.96, P < 0.001$
Non-patients	48	0.32	0.03	0.27–0.38	$Q_{47} = 59.37, P = 0.11$	

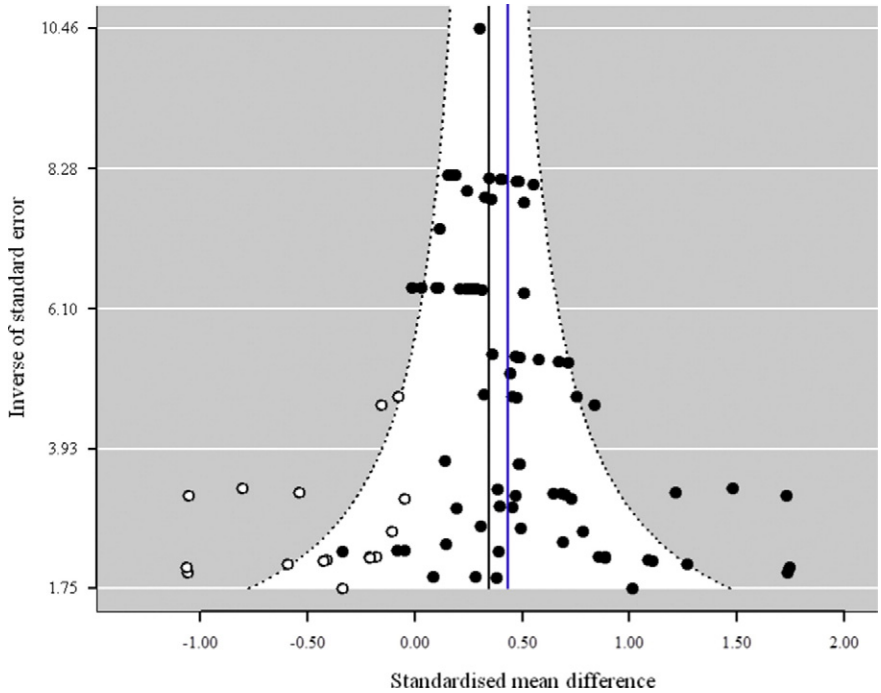

Fig. 3. A funnel plot to assess potential publication bias. Measures of effect size (standardized mean differences) and study precision (the inverse of standard error) are shown on the x- and y-axes, respectively. The filled and open circles represent observed data (76 comparisons) and data added (16 studies) by the trim-and-fill analysis (see the main text). Blue and black centerlines indicate the meta-analytical mean before (see Fig. 2) and after adding these 16 data points to the original 76 (i.e. adjusted effect size).

5. Conclusions

Our meta-analysis has provided robust evidence for the positive effects of gardening on health. With an increasing demand for reduction of health care costs worldwide, our findings have important policy implications. The results presented here suggest that gardening can improve physical, psychological, and social health, which can, from a long-term perspective, alleviate and prevent various health issues facing today's society. We therefore suggest that government and health organizations should consider gardening as a beneficial health intervention and encourage people to participate in regular exercise in gardens. To do so, policy makers need to increase people's opportunity and motivation to engage with gardening activities. The former requires enough spaces where people can enjoy gardening, and the latter needs the various advantages of gardening to be made apparent to a broad audience. Because gardens are accessible spaces for all kinds of people, including children, elderly people, and those with a disability, and relatively easily and quickly implemented in urban areas as a "land-sharing" strategy (Soga et al., 2015; Stott et al., 2015), we believe that such actions and policies would at the same time contribute greatly to redressing health inequalities.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2016.11.007.

Acknowledgments

MS was supported by the Japan Society of Promotion of Science (grant number 16K00631). KJG was supported by the Natural Environment Research Council (grant number NE/J015237/1). YY was supported by JSPS KAKENHI (grant number 26292074).

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Gardening is beneficial for health: A meta-analysis

Soga, Masashi; Gaston, Kevin J.; Yamaura, Yuichi

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Diseases of civilization are increasingly prevalent in the developed world. Primary causes being unhealthy diet, lack of exercise. Regular (daily) contact with nature appears to have positive effects on mental and physical health as well as promoting social wellbeing. A significant minority of the population enages in gardening. It may be a positive and relatively cost effective health intervention.

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This definition of health has been found to be too unattainable and has been modified to be a bit more open.

Key points are that it includes cultivating well being and the concept of thriving.

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Useful for understanding how they searched for material. How can we use this terminology for our own searches?

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09 Aaron Godlaski Page 3

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Authors focused on quantitative research, which is very helpful considering there is quite a bit of quantitative work out there as well.

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Hedges is like Cohens for small sample sizes. Multiple studies with treatment vs control conditions. They have different sample sizes, and different variances (error). If you want to compare them you must standardize them like a z score. Here we look at the difference between treatment and control divided by the shared variance. This also allows for the generation of a confidence interval. Once created these estimated difference scores can be compared across studies.

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With this many similar studies there is a risk that a positive effect could look more positive because researchers are sort of doing the same test over again (replication) and therefore inflating the effect. By repeatedly resampling subsets of the data and generating a distrubution of possible effects sizes, we can control for the possibility of pseudoreplication.

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