Title
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Journal
Journal of Health Psychology, 25(13-14)

ISSN
1359-1053

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Publication Date
2020-11-01

DOI
10.1177/1359105318800784

Peer reviewed

Article

JHP

Journal of Health Psychology
1–10

DOI: 10.1177/1359105318800784
journals.sagepub.com/home/hpq
SAGE

Cultivating healthy trajectories: An experimental study of community gardening and health

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Abstract

Advances in behavioral medicine suggest that optimal solutions to modern health challenges should be multifaceted, targeting multiple cognitions and behaviors simultaneously. Community gardening holds great promise as one such multifaceted intervention but lacks rigorous evidence of efficacy. We present one of the first experimental studies on the topic. The results revealed promise for aspects of community gardening, but also suggest the necessity for the use of rigorous methodologies moving forward. In addition, this article provides a framework for studying the effects of community gardening and similar multifaceted health promotion efforts.

Keywords

community gardening, community health, community health promotion, health behavior, health promotion

Considerable resources are spent on sundry health promotion strategies ranging from special diets to social networks to communing with nature to wrist-monitored step counts. But which core interventions are most effective and will produce meaningful health benefits? The evidence supporting much health advice is correlational and piecemeal; the field could benefit greatly from the rigorous research methods and theories of experimental health psychology. This article investigates community gardening for health promotion and presents some of the first well-controlled experimental research conducted on the topic.

Community gardening is the practice of group cultivation of fruits, vegetables, and/or ornamental plants; it is widely used in a variety of settings (Lawson, 2005) but lacks empirical evidence of when, why, and for whom it promotes health. Community gardening is an especially promising platform to study real-world pathways to health and well-being because it is a deeply rooted, multifaceted intervention that has the potential to slowly shift people onto a healthy trajectory. Community gardening requires persistence, planning, accountability, physical activity, and cooperation with others. There is significant theoretical and empirical reason to expect that each of these elements may lead to new, healthier psychosocial patterns. That is, in addition to harvesting the direct benefits of garden labor—fresh produce, exercise, and a close-to-nature scene—gardening may reinforce productive patterns (e.g. persistence, planning) in other areas of life.

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Instead of targeting a single health behavior, as exercise or diet interventions typically do, gardening holds the potential to change a range of daily emotional and health behavioral patterns—a biopsychosocial approach.

Past research

Research on gardening and health is usefully categorized into five general domains: diet, education, environmental stewardship, social competence, and psychological well-being (for reviews, see Blair, 2009; Ohly et al., 2016; Ozer, 2007; Robinson-O'Brien et al., 2009; Wang and MacMillan, 2013; Williams and Dixon, 2013 for meta-analysis see Soga et al., 2017). First, with regard to diet, gardening can lead to increased vegetable intake (Langellotto and Gupta, 2012). Relatedly, gardeners have a lower average body mass index (BMI) than non-gardeners (Zick et al., 2013)—perhaps because of the combination of a healthy diet and physical activity that gardening reportedly promotes (D'Abundo and Carden, 2008; Van den Berg et al., 2010). Second, regarding education and cognitive development, school gardens show promise for engaging students in academics (Bowker and Tearle, 2007; Graham and Zidenberg-Cherr, 2005; Somerset et al., 2005) and improving test scores, especially in science-based subjects (Dirks and Orvis, 2005; Klemmer et al., 2005; Mabie and Baker, 1996). By teaching biology, math, or even history using hands-on examples in the garden—a setting where students can move and interact—teachers may encourage deeper learning than in a traditional classroom. Third, many school garden programs have a focus on the environment, which fosters ethical and political interest in protecting the earth (Mayer-Smith et al., 2007). Fourth, various social benefits of community gardens have been documented: gardens may facilitate social capital (Alaimo et al., 2010), collective efficacy (Teig et al., 2009), and social support (Firth et al., 2011; Wakefield et al., 2007). In other words, gardens can strengthen the local social fabric. Finally, gardens may enhance individual psychological well-being (Berman et al., 2008; Van den Berg and Custers, 2011; Webber et al., 2015). Gardeners report that gardens promote relaxation, creativity, and restoration (Dunnett and Qasim, 2000), and gardeners have been shown to score higher in eudaimonic well-being and quality of life than non-gardeners (Shiue, 2015; Webber et al., 2015). One of the few true experiments on the effects of gardening found that after a stressful task, a gardening group exhibited reduced cortisol levels and reported improved mood above and beyond a reading control group (Van den Berg and Custers, 2011).

Much of this research, however, is correlational, weakly controlled, or narrowly targeted. For example, most gardening studies to date lack random assignment, thus undermining confidence that observed effects are due to gardening rather than preexisting differences, self-selection, varying situations, or other confounds and artifacts. Second, many studies do not include baseline measurements, thus limiting the precision of assessment. Third, typically only the immediate effects of gardening are measured, overlooking possible long-lasting, fundamental shifts that might change a lifestyle and thus have a more meaningful impact on wellness. In short, there is a need for true experiments of gardening that comprehensively measure lasting effects.

Perhaps the most complex and challenging limitation in the extant literature on gardening is the dearth of adequate comparison (control) groups—a key to in-depth understanding of the effects of gardening. Many studies focused on dietary impacts of school gardens have properly used nutrition education as a control group, but there is a remarkable lack of adequate comparison groups in studies of effects beyond school gardens and diet. Including proper control groups is critical to understanding causal pathways—what it is about gardening that might drive the beneficial effects. Are the effects due to being active? Being outdoors? Growing something? Simply participating in a supervised activity? Such deeper understanding is necessary both for refining the psychology of health promotion and for designing effective interventions.

We sought to discover what it is about gardening that might drive salubrious effects. We compared community gardening with four theoretically relevant comparison groups. Achieving a deeper understanding of causal mechanisms requires such an array of control groups.

Method

Design

This research was approved by the University of California, Riverside's Institutional Review Board, approval number 16-012. Participants were randomly assigned to one of five health intervention groups. In addition to a community gardening group, each of four groups was developed based on one aspect of community gardening that theory suggests might be driving beneficial effects. Specifically, existing literature suggests that the most likely pathways between community gardening and health are as follows:

1. *Physical activity*. These participants were assigned to a *moderate, indoor exercise control group*.
2. *Exposure to nature*. These participants were assigned to a *solitary, sedentary outdoor "nature exposure" control group*.
3. *Being a part of a community.* These participants were assigned to a *social film club control group*.
4. *Growing and sustaining a living thing*. These participants were assigned to an *indoor container gardening control group*.

Each comparison group is meant to examine (or qualify) a specific potential mechanism of the effects of community gardening (Davidson and Kaszniak, 2015).

Participants

A diverse group of 138 eligible undergraduate (94.9%) and graduate students at the University of California, Riverside, were recruited for participation in this study. The demographic breakdown for the full sample was 37.7 percent Hispanic, 31.2 percent Asian American, 13.8 percent White, 6.5 percent Black, and 10.8 percent other; majority female (68.8%), with a mean age of 20.6 (standard deviation (SD) = 3.30). Pre- and post-data were collected for 110 participants (71.8% female; 93.6% undergraduate), who had a mean age of 20.6 (SD = 3.32). (See Supplement A for a comparison of participants who completed pre and post measures versus those who did not.) The study had 80 percent power to detect small interaction effects (i.e. η^2_p of 0.014). Data on the complete sample were collected prior to the data analysis.

Recruitment and compensation

Participants were recruited using flyers, promotional emails, communication with campus clubs, and via the Psychology Subject Pool. Participants earned drawing entries (for later prizes) for completing each part of the study. Prizes included health-relevant items (e.g. heart rate monitors, sleep trackers, and hydration backpacks), and were distributed after the completion of the data collection. Eligible participants also received Subject Pool credits.

Eligibility

Participants were asked for verbal confirmation that they could "partake in activities such as walking, gardening, watching films, eating fresh food, communing with nature, dancing, and playing video games."

Study timeline

After recruitment, participants came to the lab and were randomly assigned to a condition and provided with written consent forms. After consenting with a signature, the participants completed baseline (pretest) measures. Thereafter, participants scheduled attendance at an orientation workshop about their assigned health behavior. Beginning the week after the workshop, all participants engaged in their assigned behavior for 4 weeks. Participants returned to the lab to complete posttest measures 1–2 weeks after the final intervention week. See Supplement B for a timeline of the study.

Experimental conditions

Participants were randomly assigned to one of the five experimental conditions: community gardening ($n=21$), moderate indoor exercise ($n=21$), exposure to nature ($n=23$), a social film club ($n=22$), and indoor container gardening ($n=23$). (Ns reported here are the participants who completed both the pre- and the posttest. There was no differential attrition by group; see Supplement A for more detail.) All participants were instructed to spend 2 hours (and no more than 3 hours) a week for 4 weeks engaging in their assigned health behavior. Participants who worked at the community garden could take home the harvested produce. Thus, to minimize the possible confounding effect of availability of produce in measures of diet, participants in all other conditions were also provided with fruits and vegetables.

Manipulation check

All the participants provided evidence to document that they engaged in each weekly behavior as scheduled by sending a date-stamped photo of their activity. For example, participants sent a photo of their indoor exercise video, of the community garden, and so on. Participants who failed to submit at least one photo by Thursday of each week were contacted and encouraged to participate in their assigned activity. If a photo was still not uploaded by Saturday, participants were contacted to confirm that they did not engage in their assigned behavior and to encourage participation in the coming week.

Because participants in the Film group met in the lab weekly to watch and discuss a short film, the experimenter confirmed that they attended. To minimize unintended differences between groups due to the manipulation check (i.e. sending a photo), participants in the Film group were also asked to send in weekly photos that reminded them of that week's movie.

Measures

Comprehensive measures were taken at two time points. A pretest assessed the baseline for each group and was used to identify any preexisting differences among groups. A posttest was completed 1–2 weeks after the completion of the 4-week intervention. Scales used and reliability alphas for scales at pre- and posttest can be found in Supplement C. Pre- and posttest measures were completed in the lab using Qualtrics, an online survey platform tool.[1]

Forming composites: five broad domains

A wide and deep range of valid measures were collected and reduced into composite measures in order to produce highly reliable indexes, to insure content validity across the range of relevant health behaviors, and to reduce the total number of statistical analyses, thus reducing the likelihood of Type I errors. Initial groupings of composite scores were based upon a priori theory-based plans to measure five broad domains and on inter-scale zero-order correlations. A factor analysis yielded a check of the initial groupings and suggested minor restructuring of composites. The five-factor solution to the factor analysis accounted for 55.89 percent of the variance of measured variables. The reliability analyses (Supplement D) confirmed good reliability of the resulting composite scales. The composite scales were as follows:

1. Emotional well-being.
2. Conscientiousness and persistence.
3. Social relationships.
4. Environmental identity.
5. Self-reported health.

Self-reported health behaviors, including fruit consumption, vegetable consumption, sleepiness, alcohol consumption, and physical activity were not included in the data reduction. Fruit and vegetable consumption were averaged

Table 1. 2 (Time) × 5 (Group) ANOVA Results.

Composite/Scale	*df*	*F*	*p*-value	η^2_p
Emotional well-being				
Effect of time	(1,105)	28.00	$<0.001^{**}$	0.21
Time × Condition	(4,105)	0.41	0.80	0.02
Conscientiousness/productivity				
Effect of time	(1,105)	4.82	0.03^{*}	0.04
Time × Condition	(4,105)	0.85	0.50	0.03
Social relationships				
Effect of time	(1,105)	13.57	$<0.001^{**}$	0.11
Time × Condition	(4,105)	0.51	0.73	0.02
Environmental identity				
Effect of time	(1,105)	4.94	0.03^{*}	0.04
Time × Condition	(4,105)	2.72	0.03^{*}	0.09
Self-reported health				
Effect of time	(1,105)	14.61	$<0.001^{**}$	0.12
Time × Condition	(4,105)	0.65	0.63	0.02
Sleepiness				
Effect of time	(1,105)	1.87	0.17	0.02
Time × Condition	(4,105)	1.32	0.27	0.05
Physical activity				
Effect of time	(1,105)	0.21	0.65	0.00
Time × Condition	(4,105)	0.49	0.74	0.02
Produce consumption				
Effect of time	(1,105)	0.71	0.40	0.01
Time × Condition	(4,105)	0.97	0.43	0.04

$^{*}p<0.05$. $^{**}p<0.01$.

for a total produce consumption score. See Supplement D also for correlations among the five composites and health behaviors. Means and standard deviations of all variables (collapsed across groups) at both time points can be found in Supplement E. Supplement F shows means and standard deviations of the composites and health behavior variables used in significance testing organized by experimental groups.

Results

Effects of intervention: comparing group change

To compare how groups changed from baseline measures (pretest) to post-intervention measurement (posttest), 2 (Time) × 5 (Group) mixed analyses of variances (ANOVAs) were computed. See Table 1 for a summary of significance tests.

Emotional well-being: 2 × 5 ANOVA

There was an effect of time, such that regardless of group, participants increased on emotional well-being from pre- to posttest, $F(1, 105)=28.00$, $p<0.001$, $\eta^2_p=0.21$. However, groups did not change differentially over time, $F(4, 105)=0.41$, $p=0.80$, $\eta^2_p=0.02$, see Supplement G.

Conscientiousness and persistence: 2 × 5 ANOVA

There was a significant effect of time on conscientiousness, $F(1, 105)=4.82$, $p=0.03$, $\eta^2_p=0.04$, such that participants increased on the composite

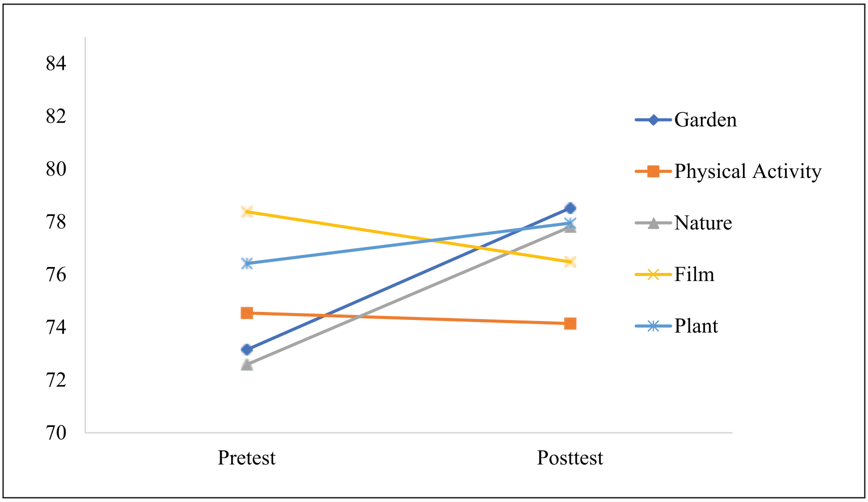

Figure 1. Environmental identity (composite) at Pretest and Posttest by experimental group.

measure of conscientiousness and persistence. There was no interaction effect, $F(4, 105)=0.85$, $p=0.50$, $\eta^2_p=0.03$, see Supplement H.

Social relationships: 2 × 5 ANOVA

There was a significant effect of time, such that participants increased on measures of social relationships over time, $F(1, 105)=13.57$, $p<0.001$, $\eta^2_p=0.11$. Change over time did not vary by group, $F(4, 105)=0.51$, $p=0.73$, $\eta^2_p=0.02$,[2] refer Supplement I.

Environmental identity: 2 × 5 ANOVA

Overall, participants increased in environmental identity from pretest to posttest, $F(1, 105)=4.94$, $p=0.03$, $\eta^2_p=0.04$. There was, however, a significant interaction, such that groups changed differentially over time, $F(4, 105)=2.72$, $p=0.03$, $\eta^2_p=0.09$.[3] Figure 1 illustrates this interaction.

Tukey's honestly significant difference (HSD) tests were conducted to tease apart group differences. The difference between the Garden condition and Film condition was trending ($p=0.08$), as was the difference between the Nature condition and the Film condition ($p=0.08$). Though not conventionally significant at the 0.05 level using the strict Tukey's HSD, these trending effects are conceptually sensible and heuristic, as we would expect the Garden and Nature groups to increase most on scales relevant to nature and the environment.

Self-reported health: 2 × 5 ANOVA

There was a significant effect of time, such that participants increased in self-reported health over time, $F(1, 105)=14.61$, $p<0.001$, $\eta^2_p=0.12$. Change over time did not vary by group, $F(4, 105)=0.65$, $p=0.63$, $\eta^2_p=0.02$,[4] see Supplement J.

Sleepiness: 2 × 5 ANOVA

There was no significant effect of time on sleepiness, $F(1, 105)=1.87$, $p=0.17$, $\eta^2_p=0.02$. There was also no significant group by time interaction, $F(4, 105)=1.32$, $p=0.27$, $\eta^2_p=0.05$, refer Supplement K.

Physical activity: 2 × 5 ANOVA

There was no significant change in physical activity over time, $F(1, 105)=0.21$, $p=0.65$, $\eta^2_p=0.00$. There was also no significant interaction between time and group, $F(4, 105)=0.49$, $p=0.74$, $\eta^2_p=0.02$, refer Supplement L.

Produce consumption: 2 × 5 ANOVA

There was no significant effect of time on produce (fruit and vegetable) consumption, $F(1, 105)=0.71$, $p=0.40$, $\eta^2_p=0.01$. There was also no significant group by time interaction, $F(4, 105)=0.97$, $p=0.43$, $\eta^2_p=0.04$, refer Supplement M.

Discussion

For socio-behavioral public health interventions to be both effective and useful, they need to be simultaneously scientifically valid and able to be integrated with the ongoing lives of individuals and communities. Gardens are widely used health interventions—based on decades of community efforts—that modify the social and built environment in an attempt to shift individual and community level patterns; however, "if," "when," and "why" gardens fully accomplish their health goals has not been comprehensively investigated. In this research, we applied well-controlled health psychology experimentation to community gardening.

Overall, we found promise for certain aspects of community gardening but also discovered the necessity for more in-depth consideration of key matters. Importantly, the results call into question the conclusions of more narrowly focused past research that *assumed* that observed positive outcomes were due to something specific about the intervention. In our experimental study of community gardening and health, we found that all participants, regardless of experimental condition, improved in emotional well-being, conscientiousness, social relationships, environmental identity, and self-reported health from pretest to posttest. That is, there was little differential effect of the conceptually different interventions.

All the conditions (month-long workshop-based manipulations) were created based on the premise that they are health-promoting and might be the reason for the positive effects of community gardening found in past work. It may be the case that all the experimental conditions had a true (independent) salubrious effect to some degree. However, that all groups improved could also be due simply to participation in a strong positive-intervention study of this sort (a Hawthorne effect), or due to an external factor affecting the entire cohort. The striking finding is that few differences emerged among groups.

Future directions

There is a diversity of often-successful efforts to promote human health via gardening, but a clear and thorough understanding of how, when, and why such programs function to help communities is yet to be uncovered. This research reveals some of the qualifications that emerge when well-controlled experimental research designs are employed, while still pointing toward promising new directions. For gardens to be considered seriously as a public health intervention, the field needs to advance the science of gardening and health in terms of causal linkages. In particular, the following should be focal points for future studies:

- Why is community gardening effective? For example, some studies focus on diet and exercise (Zick et al., 2013), while others focus on social interaction and social responsibility (Firth et al., 2011), and still others focus on exposure to (or communing with) nature (Cox et al., 2017). Designing the most effective such intervention will depend on understanding which aspects are key.
- When and for whom are community gardens effective? Is this best for people under stressful challenge (Demark-Wahnefried et al., 2018; Hartwig and Mason, 2016) or facing dislocation or in situations like prisons or hospitals (Hartig and Marcus, 2006; Van der Linden, 2015?)? And are certain aspects of gardening most beneficial for certain cases?

- Is gardening more effective than positive group activities such as book clubs, or than multifaceted interventions such as sports clubs?
- What are the optimal outcome measures and how should they be reliably and validly assessed? Should we be satisfied with improving known healthy behaviors such as increased vegetable intake and physical activity, or should we focus more on conscientiousness and social integration which are broader psychosocial patterns known to lead to health and well-being across time (Friedman and Kern, 2014)?
- What "dosage" of gardening is needed and how long do the benefits persist? How does community gardening compare with allotment gardening and home gardening, and does the type of growth (e.g. flowers, fruits, vegetables) matter for health outcomes? Are the new movements toward urban gardening and vertical gardening (Jain and Janakiram, 2016) beneficial?

This list of questions is not exhaustive, and some of these questions have been partly addressed using correlational or quasi-experimental designs (e.g. Hawkins et al., 2011; Litt et al., 2015; Morgan et al., 2010), but more rigorous experimental assessments of gardening are needed. Continual refinements in study designs will allow us to develop the most appropriate and effective interventions.

In short, to build a deep understanding of the health effects of community gardening, future studies are needed that (1) are conducted in a variety of environments with comprehensively assessed diverse populations, (2) employ random assignment to conditions, (3) incorporate theoretically relevant comparison groups, and (4) utilize highly reliable and validated assessments of health and well-being before and after the intervention. As with all field experiments, achieving these standards can be difficult and may not be realistic in every context (e.g. see Christian et al., 2014; Wells et al., 2014), but the field has developed to the point where the fruits of these efforts should be substantial.

Conclusion

In a letter to a friend, Thomas Jefferson wrote that "Cultivators of the earth are the most valuable citizens. They are the most vigorous, the most independent, the most virtuous, and they are tied to their country and wedded to its liberty and interests by the most lasting bonds" (letter to J. Jay, 23 August 1785; "The Letters of Thomas Jefferson," 2008). Is this true of modern day gardeners? If so, investing in community gardening infrastructure—in solid research-based ways—may yet prove to be of great importance to the health and well-being of individuals and communities today.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. Participants also completed brief mid-intervention measures 2 weeks into their intervention, and follow-up measures 2 weeks after the intervention. As these additional measures did not clarify or add to the outcome, these measures and results are not presented here.
2. Neither the interaction effect nor the effect of time changed when outliers (one at pretest and three at posttest) were dropped from the analysis.
3. The effect of time did not change when outliers (two at pretest and two at posttest; one outlier at each time point was the same participant) were dropped, $F(1, 103)=6.30$, $p=0.01$, $\eta^2_p=0.06$. The interaction effect became non-significant when outliers were dropped, $F(4, 103)=2.34$, $p=0.06$, $\eta^2_p=0.08$. Importantly, the participants who were outliers were assigned to the Physical

and Film conditions and had low scores, suggesting that the change in effect had to do with higher pretest scores and posttest scores in these groups (thus resulting in a less dramatic decrease compared with the Nature and Garden groups).

4. Neither the interaction effect nor the effect of time changed when an outlier (at posttest) was dropped.

Supplemental material

Supplemental material is available for this article online.

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References

Alaimo K, Reischl TM and Ober Allen J (2010) Community gardening, neighborhood meetings, and social capital. *Journal of Community Psychology* 38(4): 497–514.

Berman G, Jonides J and Kaplan S (2008) The cognitive benefits of interacting with nature. *Psychological Science* 19(12): 1207–1212.

Blair D (2009) The child in the garden: An evaluative review of the benefits of school gardening. *The Journal of Environmental Education* 40(2): 15–38.

Bowker R and Tearle P (2007) Gardening as a learning environment: A study of children's perceptions and understanding of school gardens as part of an international project. *Learning Environments Research* 10(2): 83–100.

Christian MS, Evans CE, Nykjaer C, et al. (2014) Evaluation of the impact of a school gardening intervention on children's fruit and vegetable intake: A randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity* 11(1): 99.

Cox DT, Shanahan DF, Hudson HL, et al. (2017) Doses of nearby nature simultaneously associated with multiple health benefits. *International Journal of Environmental Research and Public Health* 14: E172.

D'Abundo ML and Carden AM (2008) "Growing wellness": The possibility of promoting collective wellness through community garden education programs. *Journal of the Community Development Society* 39(4): 83–94.

Davidson RJ and Kaszniak AW (2015) Conceptual and methodological issues in research on mindfulness and meditation. *American Psychologist* 70(7): 581–592.

Demark-Wahnefried W, Cases MG, Cantor AB, et al. (2018) Pilot randomized controlled trial of a home vegetable gardening intervention among older cancer survivors shows feasibility, satisfaction, and promise in improving vegetable and fruit consumption, reassurance of worth, and the trajectory of central adiposity. *Journal of the Academy of Nutrition and Dietetics* 118(4): 689–704.

Dirks AE and Orvis K (2005) An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology* 15(3): 443–447.

Dunnett N and Qasim M (2000) Perceived benefits to human well-being of urban gardens. *HortTechnology* 10(1): 40–45.

Firth C, Maye D and Pearson D (2011) Developing "community" in community gardens. *Local Environment: The International Journal of Justice and Sustainability* 16(6): 555–568.

Friedman HS and Kern ML (2014) Personality, well-being and health. *Annual Review of Psychology* 65: 719–742.

Graham H and Zidenberg-Cherr S (2005) California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits. *Journal of the American Dietetic Association* 105(11): 1797–1800.

Hartig T and Marcus CC (2006) Essay: Healing gardens—Places for nature in health care. *The Lancet* 368: S36–S37.

Hartwig KA and Mason M (2016) Community gardens for refugee and immigrant communities as a means of health promotion. *Journal of Community Health* 41(6): 1153–1159.

Hawkins JL, Thirlaway KJ, Backx K, et al. (2011) Allotment gardening and other leisure activities for stress reduction and healthy aging. *HortTechnology* 21(5): 577–585.

Jain R and Janakiram T (2016) Vertical gardening: A new concept of modern era. In: Patel NL, Chawla SL and Ahlawat TR (eds) *Commercial Horticulture*. New Delhi, India: New India Publishing Agency, pp. 527–536.

Klemmer CD, Waliczek TM and Zajicek JM (2005) Growing minds: The effect of a school gardening program on the science achievement of elementary students. *HortTechnology* 15(3): 448–452.

Langellotto GA and Gupta A (2012) Gardening increases vegetable consumption in school-aged children: A meta-analytical synthesis. *HortTechnology* 22(4): 430–445.

Lawson LJ (2005) *City Bountiful: A Century of Community Gardening in the United States*. Berkeley, CA: University of California Press.

Litt JS, Schmiege SJ, Hale JW, et al. (2015) Exploring ecological, emotional and social levers of self-rated health for urban gardeners and non-gardeners: A path analysis. *Social Science & Medicine* 144: 1–8.

Mabie R and Baker M (1996) A comparison of experiential instructional strategies upon the science process skills of urban elementary students. *Journal of Agricultural Education* 37(2): 1–7.

Mayer-Smith J, Bartosh O and Peterat L (2007) Teaming children and elders to grow food and environmental consciousness. *Applied Environmental Education & Communication* 6(1): 77–85.

Morgan PJ, Warren JM, Lubans DR, et al. (2010) The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students. *Public Health Nutrition* 13(11): 1931–1940.

Ohly H, Gentry S, Wigglesworth R, et al. (2016) A systematic review of the health and well-being impacts of school gardening: Synthesis of quantitative and qualitative evidence. *BMC Public Health* 16(1): 286.

Ozer EJ (2007) The effects of school gardens on students and schools: Conceptualization and considerations for maximizing healthy development. *Health Education & Behavior* 34(6): 846–863.

Robinson-O'Brien RPR, Story MPR and Heim SM (2009) Impact of garden-based youth nutrition intervention programs: A review. *Journal of the American Dietetic Association* 109(2): 273–280.

Shiue I (2015) Gardening is beneficial for adult mental health: Scottish Health Survey, 2012–2013. *Scandinavian Journal of Occupational Therapy* 23(4): 320–325.

Soga M, Gaston KJ and Yamaura Y (2017) Gardening is beneficial for health: A meta-analysis. *Preventive Medicine Reports* 5: 92–99.

Somerset S, Ball R, Flett M, et al. (2005) School-based community gardens: Re-establishing healthy relationships with food. *Journal of the Home Economics Institute of Australia* 12(2): 25–33.

Teig E, Amulya J, Bardwell L, et al. (2009) Collective efficacy in Denver, Colorado: Strengthening neighborhoods and health through community gardens. *Health & Place* 15(4): 1115–1122.

The Letters of Thomas Jefferson (2008) Available at: http://avalon.law.yale.edu/18th_century/let32.asp (accessed 3 February 2017).

Van den Berg AE and Custers MHG (2011) Gardening promotes neuroendocrine and affective restoration from stress. *Journal of Health Psychology* 16(1): 3–11.

Van den Berg AE, van Winsum-Westra M, de Vries S, et al. (2010) Allotment gardening and health: A comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental Health* 9: 74.

Van der Linden S (2015) Green prison programmes, recidivism and mental health: A primer. *Criminal Behaviour and Mental Health* 25(5): 338–342.

Wakefield S, Yeudall F, Taron C, et al. (2007) Growing urban health: Community gardening in South-East Toronto. *Health Promotion International* 22(2): 92–101.

Wang D and MacMillan T (2013) The benefits of gardening for older adults: A systematic review of the literature. *Activities, Adaptation & Aging* 37(2): 153–181.

Webber J, Hinds J and Camic PM (2015) The well-being of allotment gardeners: A mixed methodological study. *Ecopsychology* 7(1): 20–28.

Wells NM, Myers BM and Henderson CR Jr (2014) School gardens and physical activity: A randomized controlled trial of low-income elementary schools. *Preventive Medicine* 69: S27–S33.

Williams DR and Dixon PS (2013) Impact of garden-based learning on academic outcomes in schools: Synthesis of research between 1990 and 2010. *Review of Educational Research* 83(2): 211–235.

Zick CD, Smith KR, Kowaleski-Jones L, et al. (2013) Harvesting more than vegetables: The potential weight control benefits of community gardening. *American Journal of Public Health* 103(6): 1110–1115.