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Title: Urban collective garden participation and health: a systematic literature review in free-living adults

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Abstract

Context: Collective gardens are increasingly considered a tool to promote health and well-being. **Objective**: In this systematic review, we critically appraise quantitative studies exploring the potential health benefits of urban collective garden participation. **Data Sources**: Articles published between January 2000 and August 2020 were used. **Data Extraction**: All original research studies reporting at least 1 health outcome associated with urban collective gardening in free-living adults from Western and other high-income countries were included. Of 1261 articles identified, 15 were included in the systematic review. Methodological quality was assessed by applying the criteria of the Quantitative Study Quality Assessment Tool.

Analysis: A wide range of health indicators were used. Collective gardening was associated with higher fruit and vegetable consumption than was nongardening. Mixed results were found for physical activity and physiological health. A positive association was found in most studies with mental health and social health. However, the vast majority of included studies were cross-sectional and presented selection bias (n = 13 of 15 for both) and very few used objective measurement methods (n = 3 of 15).

Conclusions: Longitudinal studies allowing the exploration of causal relationships are needed before the health benefits of collective garden participation suggested by existing studies can be confirmed.

Key words (3 to 5 key words or phrases); well-being; physical activity; fruit and vegetables; community garden; allotment garden.

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INTRODUCTION

In high-income countries, urban green spaces are recognized as key elements of sustainable cities because they provide unique opportunities to positively affect a wide range of health, social and environmental outcomes.[1,2] As part of the trend towards more green areas in cities, a wide range of collective gardening initiatives have occurred in urban areas as a promising way to promote healthier lifestyles and create cohesive communities involved with their living environment.[3] Collective gardens can be defined as cultivated spaces managed collectively by groups of gardeners and located at a distance from their homes.[4] Community and allotment gardens are the most common forms of collective gardens in urban areas. Community gardens are plots of land grown collectively that are primarily intended to favour social links and intergenerational exchanges among the inhabitants of a neighborhood and to raise biodiversity awareness.[5,6] Plots are rather small (≤ 20 m^2 for individual plots) and can be grown collectively or individually.[7] Allotments gardens are pieces of land subdivided into larger plots (between 100 and 500 m^2) rented to a person or a family for cultivation of their own fruit and vegetables and other produce, as well as for recreation purpose.[8,9] Larger than community gardens, allotments are usually located in the urban periphery.

Gardening, in general, has been associated with a wide range of mental and social health outcomes, such as less mood disturbance, anxiety, depression as well as better life satisfaction, quality of life, sense of community and cognitive function.[10,11] Gardening could also lower body mass index (BMI) by encouraging physical activity.[10] In older adults, it may improve overall physical condition by increasing physical-strength and ability.[11] Evidence of the positive impact of gardening on health comes from institutionalized settings (such as school, hospital, nursing home or health centre);[12–16] however, less is known about the health effects of collective gardening in free-living urban adults. Authors of a recent review and meta-analysis found

evidence of a beneficial effect of gardening in free-living adult populations in terms of BMI, nutrition and physical health compared to nongardeners, but this review did not look specifically at urban collective gardening.[17] Findings of several literature reviews indicate that collective gardens have the potential to promote health and well-being by creating opportunities for fruit and vegetable cultivation, leisure, recreation and community cohesion. However, drawing firm conclusions on urban

collective gardens from these reviews is challenging because most of them did not distinguish between the results of quantitative and qualitative studies,[18–23] targeted a specific country,[18,24,25] or a specific population,[23] studied nutritional outcomes only,[21,24] did not use a systematic literature search.[26,27] or were not specific to collective gardens (they considered vegetable production or urban gardens more generally).[3,21,22,25] Furthermore none of these previous reviews provided insights on intensity and duration of gardening.

For the present systematic literature review, we set out to identify and critically appraises all the quantitative studies analyzing the relationship between participation in a collective garden and gardeners' health status in urban free-living adults in Western and other high-income countries, considering health as a state of complete physical, mental and social well-being, as defined by the World Health Organization.[28]

METHODS

The present systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.[29] The PRISMA checklist is provided as Appendix S1 in the Supporting Information online.

Literature search

A systematic literature search was carried out using PubMed and Web of Science databases. The search strategy used a combination of comprehensive search terms, as follows: ("collective garden" OR "community garden" OR "urban garden" OR "shared garden" OR "allotment garden") AND ("health" OR "well-being" OR "nutrition" OR "diet" OR "physical activity" OR "social" OR "leisure" OR "vegetable" OR "fruit" OR "stress" OR "depression" OR "anxiety").

Inclusion and exclusion criteria

The Population, Intervention, Comparison, Outcomes, and Study (PICOS) design criteria were used to identify all the quantitative research studies that examined the relationship between participation in an urban collective garden and health that were eligible for the present literature review (**Table 1**). All original articles in English, published in peer-reviewed journals from January 2000 to August 2020 and reporting ≥1health outcomes associated with urban collective gardening in free-living adults were included. Studies were excluded from the analysis if they *1)* referred to gardening without additional details, home gardening, ornamental gardening or other forms of gardening not undertaken in a collective garden; *2)* evaluated gardening programs performed in specific settings such as hospital, nursing home, health center, prison or refugee camp; *3)* targeted participants younger that 18 years; *4)* were carried out in rural areas or in developing countries; and *5)* were based only on qualitative data. Literature reviews, case reports, theses and dissertations, letters, book chapters and authors' comments were also excluded. On the basis of the definition of the US 2000 Census, gardens were considered urban if they were located within areas that have a population density of ≥1000 persons per square mile and a minimum total population of 50 000.[30]

Literature search strategy and data extraction

Figure 1 presents the PRISMA flowchart describing the identification, screening, and selection process of the literature search. The literature search was conducted by the lead author and yielded 1261 records (after duplicate removal). The selection was done in 3 phases. First, title and abstract were screened and 1219 records not meeting the inclusion criteria of the review were excluded. When there was any doubt, the study was kept for additional scrutiny. Second, for the remaining records, full-text articles were screened, and 30 studies were excluded, yielding 12 full-text articles. Two studies, 1 indicated as urban without additional details,[31] and the other with the majority of gardeners coming from urban area[32] were included in the 12 identified studies. Another study in which data on people participating in community gardens or beautification projects were combined was also included in the 12 studies, because most participants were involved in both activities.[33] Finally, 3 original research studies were added to the 12 studies on the basis of expert consultations and bibliographies of articles published by researchers, leading to a total of 15 articles included in the present literature review.

For each article, the following information was extracted: author names, year, setting, participant characteristics, sample size, study design, data collected, assessment tools, health outcomes and information on length and frequency of gardening (**Table 2**).[31,32,41–45,33–40]

Quality assessment

The methodological quality of the included studies was assessed using the Quantitative Study Quality Assessment Tool developed by the Effective Public Health Practice Project (EPHPP).[46] The tool assesses 6 domains : selection bias, study design, confounders, blinding,

data collection methods, withdrawals and drop-outs. According to the tool guidelines, each domain was rated as of "strong", "moderate", or "weak" quality. The quality assessment was performed independently by both authors. Disagreements were resolved by consensus.

RESULTS

Study characteristics

Eight of the 15 eligible studies were conducted in the United States,[31,33–36,38,39,45] 6 were conducted in in Europe (2 in the Netherlands,[32,43] 1 in the United Kingdom,[37] 1 in France,[40] 1 in Portugal,[41] and 1 in Switzerland[44]), and 1 in Japan.[42] In the studies conducted in the US and the one in France , researchers examined community gardens (n = 9) [31,33–36,38–40,45] and the others allotment gardens (n= 6).[32,37,41–44] One study targeted an elderly population[37] and 3 studies targeted low-income populations.[31,35,40] The mean age of collective gardeners ranged from 41 to 66 years. Sample size varied from 65 to 13 133 with a mean number of collective gardeners of 91.

Of the 15 studies included, 13 were cross-sectional, 1 was a post-test-only study[45] and 1 a randomized control trial (RCT).[43] In 11 studies, the comparison group comprised nongardeners[31,32,34,40,42,45], home gardeners[35,44] or both.[36,38,39] Allotment and home gardeners were compared in 1 study to members of outdoor-walking groups and indoor-exercise groups.[37] In another study, researchers compared community gardeners to participants of neighborhood association meetings, individuals participating in both gardens and association meetings, and individuals not participating in any of these activities.[33] One study had no comparison group.[41] The RCT compared 2 groups of allotment gardeners participating either in gardening activities or indoor reading.[43] Regarding sampling, 2 studies used data from a representative survey of

the general population,[33,34] 4 used multiframe sampling design to increase the proportion of gardeners,[36,38,39,44]. The other studies were based on convenience samples.

In terms of health outcomes, most of the articles examined physical health (n = 10), followed by mental health (n = 7) and social health (n = 6). Physical health was investigated through dietary behaviours (n = 5), anthropometric outcomes (n = 5) physical activity (n = 3), or other physical health outcomes (n = 4). In 3 of the 15, researchers used objective measurement methods.[37,40,43]

Collective gardening and dietary behaviours

Gardeners' diets were examined in 5 studies, all of which were cross-sectional.[31,34,35,38,40] The main outcomes were fruit and vegetable intake,[31,38] only vegetable intake,[35] monthly household food supplies,[40] or soda and fast-food intake.[31] Regarding the assessment tools, 3 studies used standardized questionnaires (the Behavioral Risk Factor Surveillance System questionnaire[34,38] and the Food behavior checklist from Expanded Food and Nutrition Education Program[35]), 1 study used self-reported frequency of fruit, vegetables, soda and fast-food intake,[31] and in 1 one study, researchers objectively recorded monthly household food supplies.[40] Three studies were conducted in low-income populations.[31,40,47]

All studies observed a positive relation of collective garden participation on fruit and vegetable consumption.[31,34,35,38,40] One study showed that community and home gardeners reported having doubled their vegetable intake as a result of gardening, to a level meeting the 2.5 daily servings recommended by the US Dietary Guidelines.[35] In another study, researchers also found a higher frequency of vegetable consumption in collective gardeners than in nongardeners, although fruit, soda and fast-food frequency consumption did not differ.[31] One US study based on a representative survey of the general population showed that adults with ≥1

household member who participated in a collective garden consumed fruit and vegetables an average of 1.4 more times than individuals from nongardener households and were more likely to consume fruits and vegetables at least 5 times daily.[34] Similarly, in another study, community gardeners were found to consume fruit and vegetables an average of 1 more times per day than nongardeners.[38] Finally, the study recording household food supplies showed that the gardeners' supplies contained more fruit and vegetables than those of the nongardeners (approx. +158 g/day.person), whereas there was no difference for other food categories.[40] In that study, the fruit and vegetables difference was mainly due to quantities purchased, the quantities produced in the garden averaging 28g/day.person in the household (including potatoes and pulses).[40]

Collective gardening and anthropometric outcomes

In 5 studies, anthropometric outcomes were assessed using BMI as the only measure.[35,37,39,42,45] Four studies were cross-sectional.[35,37,39,42] Four studies estimated BMI on the basis of self-reported height and weight[35,39,42,45] and one study used objective measurements.[37]

In 3 of the 4 cross-sectional studies, no significant difference in BMI was found between gardeners and the comparison group. Comparison groups used in these studies included home gardeners,[35] nongardeners,[42] or members of outdoor-walking or indoor-exercising groups.[37] Authors of another cross-sectional study observed a lower BMI among gardeners than nongardeners.[39] In the post-test-only study, collective gardeners had a lower BMI than their same-sex siblings or neighbors (BMI range, −2.36 to −1.33, calculated as kg/m^2), whereas no significant difference in BMI was observed with nongardening spouses of the gardeners.[45]

Collective gardening and physical activity

Collective gardeners' physical activity was examined in 3 studies.[31,32,37] All were cross-sectional and used questionnaires to assess physical activity. One study used 2 items from the Short QUestionnaire to ASsess Health enhancing physical activity,[32] another one used a questionnaire that asked for self-reported frequency of moderate and vigorous physical activity questionnaire,[31] and the short form of the International Physical Activity Questionnaire was used in the third study.[37]

A positive association between collective gardening and physical activity was reported in 1 study: gardeners, regardless of age, reported performing moderate physical activity more frequently than their neighbors, but only during the summer.[32] Another study, conducted in a low-income population, found no difference in moderate and vigorous physical activity between collective gardeners and nongardeners.[31] In the third study, conducted in an elderly population, intensities of physical activity and sitting time were similar between individuals performing community gardening, home gardening, walking outdoors or exercising indoors.[37]

Collective gardening and other physical health outcomes

In 4 studies, researchers assessed other physical health outcomes, namely self-perceived general health,[10,31,32,37] subjective health complaints,[10,32] physical constraints (limitation in the performance of several daily activities of low to vigorous intensity due to health condition),[32] consultations with the GP,[32] blood pressure[37] and lung function.[37] All studies were cross-sectional. Self-perceived general health was measured with standardized questionnaires using a single-item[10,31,32] or the physical section of the Quality of Life Questionnaire (short form-36, version 2, of the Health Survey).[37] Physical constraints were assessed by the physical functioning subscale of the short form-36. [32] Subjective symptoms were evaluated via a

symptom checklist.[10,32] Consultations with the general practitioner were also self-reported by participants.[32] Blood pressure and lung function were measured.[37]

A positive association between gardening and ≥ 1 physical health outcome was found in 2 studies.[32,42] Regarding self-perceived general health, that collective gardeners reported better self-perceived general health and fewer subjective health complaints than nongardeners in 1 study,[42] whereas in another study, no difference was found in self-perceived general health between gardeners and nongardeners in a low income population.[31] In a study where the gardener sample was split according to age (<62 years old and ≥62 years old.), the older gardeners only scored significantly better than nongardener neighbors of the same age category on physical constraints (locomotor activity limitation), subjective health complaints and consultation with general practitioner.[32] Finally, in 1 study in which different leisure activities in an elderly population were compared, no differences were found in blood pressure, lung function, and general physical health among individuals participating in collective gardens, home gardens, outdoor-walking groups, or indoor-exercising groups.[37]

Collective gardening and mental health

Collective gardeners' mental health was examined in 7 studies through various indicators such as stress,[32,37,43,44] psychological distress,[31,42] life satisfaction,[31,32] subjective happiness,[41] mood,[43] psychological well-being,[31] individual empowerment,[31] general mental health,[37] and self-reported restoration.[44] All were cross-sectional, except 1 RCT.[43] All the studies relied on subjective measurements of mental health outcomes, except the RCT, in which salivary cortisol, a robust endocrine biomarkers of stress, was analyzed.[43]

All studies reported ≥1 positive association between collective garden participation and mental health outcomes. In a study targeting a low-income population, researchers found that

collective gardeners had greater psychological well-being and lower psychological distress than did nongardeners, whereas no significant difference was observed for individual empowerment and life satisfaction between groups.[31] Similarly, in another study, psychological distress levels assessed with the General Health Questionnaire (a common measure of minor psychiatric disorders in the general population) were lower among collective gardeners than for nongardeners.[42] In a study comparing different levels of collective garden attendance, researchers observed that greater attendance was associated with better subjective happiness among gardeners.[41] Using structural equation model, 1 study showed that collective gardening was associated with a higher level of restoration (ie, stress-reducing effects of natural settings) through processes of perceived restorativeness.[44] In comparing gardeners from different age groups, authors of 1 study reported that gardeners aged ≥ 62 years reported less stress and better life satisfaction than both younger gardeners and nongardener neighbors.[32] Compared to indoor exercising, collective gardening was also associated with lower perceived stress in elderly population, although there was no difference in general mental health between groups.[37] The beneficial effect of collective gardening on short-term restoration from stress suggested by the cross-sectional studies, was supported by the experimental study. In the RCT, stress-relieving effects of 30-min session of outdoor gardening was compared with indoor reading (within gardeners' plot) after performing a stressful task.[43] The outdoor gardening activity was found to induce a greater decrease in salivary cortisol and a higher increase in self-reported positive mood than the indoor reading.[43] Finally, gardening (in general) can also be a source of stress as suggested by 1 study, although in this study, collective gardeners reported less garden-related stress than did home gardeners.[44]

Collective gardening and social health

The relation between the social health and collective gardening was examined in 6 studies through various indicators such as perceived social support,[37] neighborhood attachment,[36] social cohesion,[42] loneliness,[32] contact with friends,[32] social capital,[33] neighborhood norms and values,[33] sense of community,[31] and community and organisational empowerment.[31] All the studies were cross-sectional and relied on subjective measurement of social health outcomes.

Five of the 6 reported ≥ 1 positive association between collective garden participation and social health outcomes.[31–33,36,42] Collective gardeners from a low-income population reported higher sense of community, community empowerment and organizational empowerment than did nongardeners.[31] One study showed that collective gardeners had better social cohesion than nongardeners.[42] Authors of another study also found a higher level of neighborhood attachment among gardeners than in nongardeners.[36] Similarly, 1 study based on a representative survey of the general population showed that adults with at least one household member who participated in community gardens or beautification projects reported higher levels of bonding and linking social capital, as well as stronger neighborhood norms and values (such as neighborhood involvement, satisfaction or collective efficacy) compared to individuals from households who neither participated in these activities or in neighborhood meetings.[33] In 1 study, collective gardeners aged ≥62 years reported less loneliness than did nongardener neighbors from the same age group, whereas no similar difference was found between younger groups of gardeners and nongardeners.[32] In the same study, collective gardeners aged ≥ 62 years also reported more frequent contact with their friends compared to younger ones, whereas no such difference was found in nongardener neighbors.[32] Conversely, another study comparing different leisure activities in an elderly population found no difference in social support between

295 collective gardeners, home gardeners and members of outdoor-walking groups or indoor-
296 exercising groups.[37]

297

298 **Length and frequency of gardening**

299 Length of gardening time was specified in 4 studies and ranged from <1 month to 20
300 years.[32,35,40,45] None of the studies evaluated the effect of length of gardening on health
301 outcomes.

302 Frequency of gardening was specified in 5 studies, and ranged from every day to less
303 than once a month.[31,32,41,42,44] In 1 study, frequency and duration of gardening were not
304 associated with any of the investigated health outcomes.[42] Conversely, in 1 study, researchers
305 reported higher levels of happiness among collective gardeners who visited the garden daily
306 than for those visiting the garden less regularly.[41] Another study also showed that the effect of
307 gardening frequency differed across health outcomes: regular participants going to the garden
308 >12 times per year reported more sense of community, whereas occasional participants reported
309 higher vegetable intake.[31] The relationship between frequency of gardening and health
310 outcomes also depended on the type of activities performed in the garden. One study found a
311 positive relationship between well-being and percentage of time spent on gardening and
312 maintenance activities relative to time spent sitting, reading and enjoying the garden.[32] Finally,
313 gardening frequency was assessed in 1 study, but researchers not evaluate its association with
314 health outcomes.[44]

315

Quality assessment

Results of the quality assessment for each of the 6 domains of the EPHPP (ie, selection bias, study design, confounders, blinding, data collection methods, withdrawals and drop-outs) are presented in **Table 3**.[31,32,41–45,33–40] Selection bias (first EPHPP domain) was likely in many studies. Two studies, using respectively, a random sampling method with high level of participation[33] and population databases[45], were at moderate risk of selection bias; the others studies based on a random sampling method but with participation rate <60%[34,36,38,39,44] or based on convenience samples[31,32,35,37,40–43] were rated as weak. Regarding study design (second EPHPP domain), the RCT[43] and the post-test-only study[45] were respectively rated as strong and moderate, whereas the other studies were considered weak because of their cross-sectional design. In terms of confounders (third EPHPP domain), the majority of studies controlled for potential confounders and were rated as strong (n = 9)[32–34,36,38,39,42–44] or moderate (n = 2).[31,45] Regarding blinding (fourth EPHPP domain), 4 studies used data from population-based surveys and were rated as moderate because participants were not aware of the research question.[34,36,38,39] The other studies were rated as weak. In terms of data collection methods (fifth EPHPP domain), studies mainly used widely used and well-established self-reported assessment tools and, therefore, were rated as strong (n = 9)[33,34,36–38,41–44] or moderate (n = 6).[31,32,35,39,41,45]. The withdrawals and drop-outs assessment (sixth EPHPP domain) was applicable only to the RCT[43] and the post-test-only study,[45] which were rated as strong.

DISCUSSION

A total of 15 quantitative studies on the relationships between urban collective garden participation and health status in free-living adults from western and other high-income countries were identified and included in this literature review. Half of them (n = 7) were

published in the past 5 years, with only 1 published before 2010, showing a recent but growing scientific interest in collective gardens as tools to promote the health and well-being of urban dwellers.

The health status of gardeners was assessed in its physical, mental and social dimensions. Although some conclusions diverge, all the studies demonstrated a positive association between collective gardening and at least one health indicator, suggesting that gardeners benefit from physical and social environment, and psychological conditions conducive to health and well-being. The frequency of fruit and vegetable consumption and participants' BMI were the most investigated variables. A positive association was observed between collective gardening and fruit and vegetable consumption.[31,34,35,38,40] It is hypothesized that gardening, by increasing the ready availability of fresh produce from the garden, encourages the consumption of fruit and vegetables. However, in the study objectively measuring the quantity of produce from the collective garden in monthly household food supplies, this quantity was negligible and the higher fruit and vegetable supplies observed in gardeners' versus nongardeners' households were due to more purchases of those items.[40] Additional studies are needed to ascertain whether the higher consumption of fruit and vegetables among gardeners is due to the produce from their gardens or to healthier behaviors that the gardeners already had beforehand or developed through gardening. Regarding BMI, conflicting results were obtained : in 2 studies gardening was inversely associated with BMI,[39,45] whereas no association with BMI was found in 3 studies.[35,37,42] For the other indicators of physical health, the limited number of studies and their conflicting results make it difficult to draw conclusions about the beneficial effect of collective gardening. Moreover, the findings of the present review suggest that collective garden participation has the potential to enhance mental well-being by its positive relationship with life satisfaction, happiness and restoration, and its inverse relationship with level of stress and mood disturbance. Collective gardening is

365 also likely to enhance social health and community cohesion by its positive effect on social
366 capital, social cohesion, sense of community, community empowerment or neighborhood
367 attachment.

368 The quality assessment of the included studies highlighted methodological weakness of
369 the existing literature on collective garden participation and health of urban adults. Because
370 cross-sectional design does not allow for causal assessment, it is not possible to determine
371 whether observed differences between gardeners and nongardeners were due to a selection bias.
372 . Namely, it is possible that the gardeners surveyed in the cross-sectional studies are those who
373 have persevered in the gardening activity and therefore present different characteristics from
374 the general population, such as being already committed to healthy eating, regular physical
375 activity, frequent contact with the natural environment, and social relations. Causality is an
376 essential concept in public health to understand the impact of an intervention on outcomes,
377 contributing to the implementation of effective programmes or policies that promote population
378 health and well-being.[48] Another cause of weakness in almost all the studies was the use of self-
379 reported questionnaires subject to desirability and memory bias.[49] Fruit and vegetable
380 consumption, in particular, was assessed by short questionnaires. Although such questionnaires
381 can collect large amounts of data from large samples rapidly and cost-effectively, they lack
382 precision,[50] and their validity remains moderate.[51] No study used rigorous methods of dietary
383 assessment (eg, multiple 24-hour recalls) or biomarkers of fruit and vegetable intake. Besides,
384 no study directly assessed physical activity and sedentary behaviours using direct measures
385 (such as activity monitors, heart rate monitors or pedometers). Objective measures of physical
386 activity are more accurate than questionnaires at predicting sedentary behavior, because they
387 provide a more robust assessment of energy expenditure and levels of physical-activity
388 intensity, especially of light activity.[52–55] Such measures should be preferred to assess the
389 impact of lifestyle-related physical activity interventions in free-living conditions.[55]

An increasing number of experimental studies have been conducted to evaluate the beneficial effects of different forms of gardening on health, although, so far, none has focused on urban collective gardens. In school settings, several gardening interventions were effective at improving children's fruit and vegetable consumption, knowledge and attitudes towards fruit and vegetables, BMI, waist circumference as well as physical activity and academic performance.[14] Home gardening was also shown to be an effective way to improve fruit and vegetable consumption and physical performance among cancer survivors,[56,57] and horticultural therapy improves cognitive function, agitation, positive emotion and engagement in people suffering from mental health problems.[15,16]

Two longitudinal studies have been recently carried out in France[58] and the US.[59] to explore the causal relationships between community gardening and health of urban adult populations using rigorous quantitative methods to assess diet and physical activity. While the results of the US study are yet not available, those of the French have just been published.[58] This quasi-experimental study found no positive impact of the first year of community gardening on healthiness of household's food supplies, physical activity, BMI, mental well-being and social health, connection to nature, sensibility to food waste, as well as, the environmental impact and expenditure of food purchased. Qualitative interviews revealed several barriers to the participation such as lack of time, lack of gardening knowledge, physical difficulty of gardening, health problems and conflicts with other gardeners, possibly explaining the lack of impact and confirming the importance of mixing quantitative and qualitative approaches in intervention research studies.

The results of this systematic literature review suggest that collective gardening could help meeting recommended consumption of fruit and vegetables in low-income populations. [31,40,47] This is consistent with findings from a previous literature review in which the authors evaluated the benefit of community gardens on health and wellbeing amongst vulnerable populations,

especially socially disadvantaged individuals or households, ethnic minorities and refugees.[23] In the latter review, which mixed urban and rural settings, different age groups and quantitative and qualitative methods, most of the studies were carried out in the US. Because of strong economic, physical, and social disparities in US neighborhood environments, disadvantaged populations and minorities have low access to healthy and affordable foods, as well as recreation facilities[60,61]; thus, community gardens may be a key tool to tackle health inequities in such a context. Nevertheless, a survey conducted on food-insecure households in Toronto, Canada revealed that very few of these households take advantage of the community gardens because they considered that gardening programs are not suited to their busy schedules, interests, or needs.[62,63] More studies are needed on populations of different socioeconomic status and in various settings to extend the existing literature.

Several interventions with elderly people in nursing homes have shown a positive effect of gardening on loneliness,[64] stress,[65] depression,[66,67] quality of life,[64,66] relationships with others,[66,68] sense of community,[64] and physical performance,[65,67] as well as markers of chronic diseases.[68,69] Studies evaluating therapeutic gardening programs were nevertheless excluded from this review to better assess the effect of collective gardening on healthy urban dwellers in free-living conditions. One study in the review highlighted the potential contribution of collective gardens to an active and healthy lifestyle, especially among the elderly,[32] albeit the cross-sectional design did not allow for causal inference. Conducting interventions in noninstitutionalized settings is necessary to evaluate if collective gardening can promote healthy aging of urban dwellers by limiting risks of chronic health conditions, physical decline, mental disorders and social isolation.

Compared to gardening in institutionalized settings, where the activity is supervised and scheduled weekly, participation in a collective garden depends mainly on spare time of each individual. The results showed that frequency of gardening was highly variable and ranged from

an everyday routine to a few visits per year. It may be that the longer the exposure to a collective garden, the greater the effect will be, and so the impact of collective gardening on health status will depend on the frequency of the activity. However, the level of gardening required to see a health benefit cannot be clearly determined from the literature, and the few studies investigating the health effect of length of gardening or frequency of gardening have yielded inconsistent results.[31,41,42] More research is needed to understand the roles of duration and frequency of gardening exposure in inducing health benefits.[70]

Strength and limitations

Several previous literature reviews have addressed the health effects of gardening through different formats of gardening and within various populations. To our knowledge, the present review is the first to provide a critical appraisal of all the quantitative literature (available until August 2020) on urban collective gardening and health in free-living adults from western and other high-income countries. One strength of this review is the use of a systematic approach based on the PRISMA methodology. To better evaluate the potential of collective gardens as tools to promote the health of urban dwellers, narrow inclusion criteria were used, which resulted in the exclusion of studies that mixed collective and home gardens,[71] rural and urban areas,[72] or that were not carried out in an urban area as defined by the US 2000 Census.[73] Studies from low-income countries were also excluded collective gardens are being used to support communities' livelihood rather than for recreational or educational purposes.[74] Because several therapeutic and school gardening programs have proven their effectiveness in improving participant's health and well-being,[12–16] the present review was restricted to studies conducted on data from free-living urban adults, and for this population, but limited evidence of health benefits of urban collective gardening was found.

Another strength of this review is the evaluation of the methodological quality of included studies, using the EPHPP assessment tool. The EPHPP assessment tool has both content and construct validity[75,76] and was judged to be an appropriate tool to be used in the systematic review of non-randomised studies.[46,77] Although EPHPP assessment tool was designed to evaluate a range of study designs of various public health topics, it might not be fully appropriate to adequately discriminate the quality of complex community-based interventions such as the ones on gardening, which cannot be blinded, can hardly reach a high participation rate, have inherent selection bias (ie. participants must be interested in gardening), and generally assess multiple outcomes.

CONCLUSION AND RESEARCH DIRECTIONS

The literature on the relationship between collective garden participation and gardeners' health and well-being in free-living urban adults remains limited. Several studies have found a positive association between collective garden participation and physical, mental or social health, but the results come mostly from cross-sectional studies. Experimental or quasi-experimental studies with presence of a control group, sufficiently large samples, validated measurement methods and dose-response analysis are needed to rigorously explore the causal relationships between collective gardening (and its intensity) and health status. Positive results from such studies would then make a compelling case for the use of community gardens as a tool to promote the health of urban dwellers.

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Competing interests

The authors declare that they have no competing interests.

Author contributions

M.T and N.D. contributed to the design and methodology of the review. M.T. searched and screened the literature and extracted the data. M.T and N.D. performed quality assessment. M.T. collated the results and drafted the manuscript. All authors contributed to the critical review of the manuscript.

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TABLE LEGEND

Table 1. PICOS criteria for inclusion and exclusion of studies

Table 2. Descriptive characteristics of included studies on health benefits of participation in an urban collective garden[α]

Table 3. EPHPP Quality Assessment of Included Studies

FIGURE LEGEND

Figure 1. PRISMA flow diagram

Table 1. PICOS criteria for inclusion and exclusion of studies

Parameter	Inclusion criteria	Exclusion criteria
Population	Free-living adults (i.e., non-institutionalized) aged ≥ 18 years living in urban area of western and other high-income countries	Population aged <18 years Institutionalized settings (hospital, nursing home, health center, prison or refugee camp) Rural areas Low-income countries
Intervention	Participation in a collective garden	Gardening without further details Home gardening Ornamental gardening Therapeutic gardening Other forms of gardening not undertaken in a collective garden
Comparison	Not applicable	Not applicable
Outcomes	Any physical, mental, or social quantitative health outcomes	Qualitative data Non-health-related outcomes
Study design	Original research studies of any interventional or observational design	Literature reviews, case reports, theses and dissertations, letters, book chapters, authors' comments, and other grey literature

Table 2. Descriptive characteristics of included studies on health benefits of participation in an urban collective garden

Reference	Setting	Study design	Population, Study groups (G1, G2…)	Mean age (year); % women	Length and frequency of gardening	Data collected *(Assessment tools)*	Main results[a]
Alaimo et al. (2008)[34]	Flint, MI, USA	Cross-sectional, random sample representative of the general population, comparison group	n = 766 households with: G1: at least 1 community garden member (n = 116) G2: no community garden members (n = 650)	43.8; 51.9	NS	Dietary behaviors: Fruit and vegetable intake *(BRFSS)*	Participants in G1 consumed fruits and vegetables 1.4 more times per day than those in G2, and were 3.5 times more likely to consume fruits and vegetables ≥5 times daily.
Alaimo et al. (2010)[33]	Flint, MI, USA	Cross-sectional, random sample representative of the general population, comparison groups	n = 1916 households participating in: G1: community garden or beautification project (n = 271) G2: neighborhood association meetings (n = 129) G3: both G1 & G2 (n = 292) G4: neither G1 nor G2 (n = 1224)	G1: 40.7; 54.3 G2: 45.9; 47.7 G3: 43.8; 47.7 G4: 45.5; 56.7	NS	Social health: • Bonding social capital *(12-item Q)* • Linking social capital *(3-item Q)* • Neighborhood norms and values *(14-item Q)*	Households participation in G1, G2 or G3 was associated with better social outcomes when compared to G4. Associations with participation in group G3 were higher than for participation in groups G1 or G2.
Algert et al. (2016)[35]	San Jose, CA, USA	Cross-sectional, convenience sample, comparison group	n = 135 adults, low-income population: G1: home gardeners (n = 50) G2: community gardeners (n = 85)	G1: 49; 84 G2: 58; 50	Length of time: G1: 48 % with <2 years of experience G2: 33 % with <2 years of experience	Dietary behaviors: Vegetable intake *(food behaviour checklist from the EFNEP + 1-item Q)* Anthropometric outcomes: BMI *(self-reported height and weight)*	Participants reported having doubled their vegetable intake to a level meeting the 2.5 daily servings recommended by the US Dietary Guidelines (+1.9 cups/day.person for G1 vs +2.0 cups/day.person for G2). No difference in BMI between the two groups.

Booth et al., (2018)[31]	USA Urban areas	Cross-sectional, convenience sample, comparison group	n = 115 adults, low-income population: G1: regular community gardeners (n = 16) G2 : occasional community gardeners (n = 43) G3: nongardeners (n = 56)	42.1 ; 57.8	Participation: • regular gardeners : >12 times/year • occasional gardeners : ≤12 times/year	<u>Dietary behaviors:</u> Frequency (per week) of fruit, vegetables, soda, and fast-food intake *(4-item Q)* <u>Physical activity</u>: Frequency (per week) of moderate and vigorous PA *(2-item Q)* <u>Others' physical health outcomes:</u> Self-perceived general health *(1-item Q)* <u>Mental health</u>: • Individual empowerment *(2-item Q)* • Psychological well-being *(WHO-5)* • Psychological distress *(K-6 Distress scale)* • Life satisfaction *(10-item Q)* <u>Social health</u>: • Sense of community *(13-item Q)* • Community empowerment *(4-item Q)* • Organizational empowerment *(5-item Q)*	Participants in G1 & G2 reported greater psychological well-being and community empowerment than did G3. Participants in G1 reported higher organizational empowerment than G2 & G3 participants and higher sense of community than G2 participants. Participants in G2 report consuming vegetables 1.3 more times per week and a lower psychological distress score than G3 participants. No difference in intake of fruits, soda and fast-food, PA and self-perceived general health, individual empowerment and life satisfaction between groups.
Comstock et al. (2010)[36]	Denver, CO, USA	Cross-sectional, random multiframe sample, comparison groups	n = 410 adults: G1: community gardeners (n = 31) G2: home gardeners (n = 197) G3: nongardeners (n = 182)	median age: 45 (range 18-94); NA	NS	<u>Social health</u>: Individual neighborhood attachment *(6-item Q)*	Participants in G1 & G2 reported higher levels of neighborhood attachment than G3 participants.

Hawkins et al. (2011)[37]	Cardiff, UK	Cross-sectional, convenience sample, comparison groups	n = 94 adults >50 years: G1: allotment gardeners (n = 25) G2: home gardeners (n = 21) G3: members of outdoor-walking groups (n = 25) G4: members of indoor-exercising groups (n = 23)	G1: 65.7; 8 G2: 69.5; 19 G3: 62.4; 17 G4: 72.9; 20	NS	<u>Anthropometric outcomes</u>: BMI *(objective measures)* <u>Physical activity</u>: • Frequency and duration of moderate and vigorous(min/week) *(IPAQ short-form)* • Sitting time (min/week) *(IPAQ short-form)* <u>Others' physical health outcomes:</u> • Blood pressure *(physiological measure)* • Lung function *(physiological measure)* • General physical health *(Quality of Life Q (SF-36v2))* <u>Mental health</u>: • Perceived stress *(perceived stress scale)* • General mental health *(Quality of Life Q (SF-36v2))* <u>Social health</u>: Perceived social support *(social provisions scale)*	Participants in G1 reported lower perceived stress than G4 participants (9.8 ± 5.8 vs 15.8 ± 6.1). No difference for other outcomes between groups.
Litt et al. (2011)[38]	Denver, CO, USA	Cross-sectional, random multiframe sample, comparison groups	n = 436 adults: G1: community gardeners (n = 41) G2: home gardeners (n = 208) G3: NG (n = 187)	46; 68	NS	<u>Dietary behaviors:</u> Fruit and vegetable intake *(BRFSS)*	Participants in G1 reported higher frequency of fruits and vegetables intake than those in G2 & G3 (5.0, 4.3 and 3.9 times/day respectively)
Litt et al. (2017)[39]	Denver, CO, USA	Cross-sectional, random multiframe sample, comparison groups	n = 469 adults: G1: community gardeners (n = 63) G2: home gardeners (n = 215) G3: NG (n = 191)	46.1 y 67.4 %	NS	<u>Anthropometric outcomes</u>: BMI *(self-report height and weight)*	Participants in G1 & G2 had on average a lower BMI than those in G3. In unadjusted model, BMI increased by 0.03 (kg/m^2) for every year of age increase only for G3

							participants, but the association disappeared in adjusted model.
Martin et al. (2017)[40]	Marseille, France	Cross-sectional, convenience sample, comparison group	n = 87 adults, low-income population: G1: community gardeners (n = 21) G2: nongardeners (n = 65)	G1: 52.0; 100 G2: NS; 100	Mean garden occupancy time: 21 months (range: 0-48 months)	Dietary behaviors: Monthly household food supplies including purchases and garden production *(food supply diary)*	Participants in G1 had, on average, higher fruit and vegetable food supply than G2 participants (+158 g/day.person). No difference for other food groups between groups.
Mourão et al. (2018)[41]	Vila Nova de Famalicão, Portugal	Cross-sectional, convenience sample	n = 65 allotment gardeners	• 25-45 years (37 %) • 46-65 years (48 %) • >65 years (15 %) ; 43.1	• Gardening every day (41.5 %) • Gardening several days/week (n = 47.7 %) • Gardening once a week (10.8 %)	Mental health: Subjective happiness *(subjective happiness scale)*	Participants who visited the garden more frequently considered themselves happier in comparison with peers.
Soga et al. (2017)[42]	Tokyo, Japan	Cross-sectional, convenience sample, comparison group	n = 332 adults: G1: allotment gardeners (n = 165) G2: nongardeners (n = 167)	G1: 61.9; 31.9 G2: 61.0; 58.2	Mean number of visits: 15.7 ± 10.9 times/month Mean duration of each visit: 80.0 ± 64.9 min Total mean duration of all visits: 21.0 ± 25.7 h/month	Anthropometric outcomes: BMI *(self-reported height and weight)* Others' physical health outcomes: • Self-perceived general health *(1-item Q)* • Subjective health complaints *(10-item symptom checklist)* Mental health: Psychological distress/mood disturbance *(General Health Q)* Social health: Social cohesion *(social Cohesion and Trust Scale)*	Participants in G1 reported better perceived general health and social cohesion, and less subjective health complaints and psychological distress than G2 participants. No difference in BMI between groups.
Van den Berg et al. (2010)[32]	Netherlands Urban (65 %) Peri-urban (31 %) Rural (4 %)	Cross-sectional, convenience sample, comparison group	n = 184 adults: G1: allotment gardeners ≥62 years (n = 70) G2: allotment gardeners <62 years (n = 51)	G1: 61.5; 47 G2: 55.9; 59	Length of gardening: • G1: 11-20 years • G2: 6-10 years Mean time spent on gardening and	Physical activity: Frequency of PA in summer and winter *(2-item from the SQUASH Q)* Others' physical health outcomes:	Participants in G1 and G2 reported more frequency of PA during summer than G3 and G4 (5.8 ± 1.53 vs 4.9 ± 2.15 days/week). Compared to G3, participants in G1 reported less physical constraints (1.27 ± 0.04

			G3: nongardener neighbors ≥62 years (n = 21) G4: nongardener neighbors <62 years (n = 42)		maintenance activities in the garden: • G1: 66 % • G2: 56 %	• Self-perceived general health *(1-item Q)* • Physical constraints *(physical functioning subscale of the SF-36)* • Subjective health complaints *(7-item symptom checklist)* • Chronic illnesses *(5-item illness checklist)* • Consultations with the GP *(1-item Q)* <u>Mental health</u>: • Stress (2-item Q) • Life satisfaction (life Satisfaction Index) <u>Social health</u>: • Loneliness *(2-item Q)* • Social contact with friends *(2-item Q)*	vs 1.53 ± 0.07), subjective health complaints (2.04 ± 0.26 vs 3.83 ± 0.45), consultations with their GP (0.52 ± 0.13 vs 1.14 ± 0.23) and loneliness (0.28 ± 0.09 vs 0.8 ± 0.16), as well as more life satisfaction (2.29 ± 0.06 vs 1.96 ± 0.09). Participants in G1 also reported less stress (2.05 ± 1.2 vs 3.20 ± 0.14) and more contact with friends (8.07 ± 0.38 vs 6.14 ± 0.43) than G2 participants, whereas there were no difference between G2 and G4 participants. No difference in perceived general health and chronic illnesses between groups.
Van den Berg et al. (2011)[43]	Amsterdam, Netherlands	Randomized control trial	n = 30 allotment gardeners. After performing a stressful task, participants were randomly assigned to 30 min of: G1: outdoor gardening activities (n = 14) G2: indoor reading (n = 16)	G1: 58.3; 72 G2: 57.0; 75	N/S	<u>Mental health</u>: • Salivary cortisol level *(salivary collection)* • Self-reported mood *(Positive and Negative Affect Schedule)*	Cortisol decreased from post-stressor to post-activity in both groups, but to a greater extent in G1 than in G2 (-1.45 vs -0.79 nmol/L). Positive mood increased from post-stress to post-activity by 9.2 % in G1 participants. No change in G2 participants.
Young et al. (2020)[44]	Zurich, Switzerland	Cross-sectional, random multiframe sample, comparison group	n = 301 adults: G1: allotment gardeners (n = 108) G2: home gardeners (n = 193)	G1: 59; 48 G2: 54; 67	Mean time spent in the garden: 17.6 days/month	<u>Mental health</u>: • Self-reported restoration *(1-item Q)* • Perceived restorativeness *(Perceived Restorativeness Scale)* • Garden-related stress *(1-item Q)*	Participants in G1 had higher level of perceived restorativeness than G2 participants (4.72 ± 0.47 vs 4.28 ± 0.79), which, in turn, was associated with higher level of restoration. G1 participants reported lower levels of garden-related stress than G2 participants (2.15 ± 1.23 vs 2.54 ± 1.05).

Zick et al. (2013)[45]	Salt Lake City, UT, USA	Post-test-only design, administrative database survey, comparison groups	n = 13,133 adults: G1: community gardeners (n = 198) G2: nongardener neighbors (n = 12,552) G3: nongardener siblings (n = 316) G4: nongardener spouses (n = 67)	Middle 40s to early 50s; 61.1	>1 year of gardening between 1995 and 2010	Anthropometric outcomes: BMI *(self-reported height and weight)*	Women in G1 were 46 % less likely to be overweight or obese than their female neighbors (G2). Men in G1 were 62 % less likely to be overweight or obese than their male neighbors (G2), and 37 % less likely than their siblings (G3) to be overweight or obese. No difference in BMI between G1 and G4.

Abbreviations: BMI, body mass index; BRFSS, Behavioral Risk Factor Surveillance System; EFNEP, Expanded Food and Nutrition Education Program; GP, general practitioner; IPAQ, International Physical Activity Questionnaire; NS, not significant; Q, questionnaire; SF-36, short form-36; SQUASH, Short Questionnaire to Assess Health Enhancing Physical Activity; WHO-5, World Health Organization—Five Well-Being Index.

[a] Only differences that were statistically significant are described.

Table 3. EPHPP Quality Assessment of included Studies

	Selection bias	Study design	Confounders	Blinding	Data collection[a]	Withdrawals and drop-outs
Alaimo et al. (2008)[34]	Weak	Weak	Strong	Moderate	Strong	n/a
Alaimo et al. (2010)[33]	Moderate	Weak	Strong	Weak	Strong	n/a
Algert et al. (2016)[35]	Weak	Weak	Weak	Weak	Moderate	n/a
Booth et al. (2018)[31]	Weak	Weak	Moderate	Weak	Moderate	n/a
Comstock et al. (2010)[36]	Weak	Weak	Strong	Moderate	Strong	n/a
Hawkins et al. (2011)[37]	Weak	Weak	Weak	Weak	Strong	n/a
Litt et al. (2011)[38]	Weak	Weak	Strong	Moderate	Strong	n/a
Litt et al. (2017)[39]	Weak	Weak	Strong	Moderate	Moderate	n/a
Martin et al. (2017)[40]	Weak	Weak	Weak	Weak	Moderate	n/a
Mourão et al. (2018)[41]	Weak	Weak	Weak	Weak	Strong	n/a
Soga et al. (2017)[42]	Weak	Weak	Strong	Weak	Strong	n/a
Van den Berg et al. (2010)[32]	Weak	Weak	Strong	Weak	Moderate	n/a
Van den Berg et al. (2011)[43]	Weak	Strong	Strong	Weak	Strong	Strong
Young et al. (2020)[44]	Weak	Weak	Strong	Weak	Strong	n/a
Zick et al. (2013)[45]	Moderate	Moderate	Moderate	Moderate	Moderate	Strong

Abbreviation: n/a, not applicable.

[a] Studies using half or more valid and reliable tools were rated as strong. Studies using less than half of valid and reliable tools were rated as moderate