

Community Gardens as Environmental Health Interventions: Benefits Versus Potential Risks

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Abstract

Purpose of Review The purpose of this paper was to summarize current findings on community gardens relevant to three specific areas of interest as follows: (1) health benefits, (2) garden interventions in developing versus developed countries, and (3) the concerns and risks of community gardening.

Recent Findings Community gardens are a reemerging phenomenon in many low- and high-income urban neighborhoods to address the common risk factors of modern lifestyle. Community gardens are not limited to developed countries. They also exist in developing low-income countries but usually serve a different purpose of food security. Despite their benefits, community gardens can become a source of environmental toxicants from the soil of mostly empty lands that might have been contaminated by toxicants in the past. Therefore, caution should be taken about gardening practices and the types of foods to be grown on such soil if there was evidence of contamination.

Summary We present community gardens as additional solutions to the epidemic of chronic diseases in low-income urban communities and how it can have a positive physical, mental and social impact among participants. On balance, the benefits of engaging in community gardens are likely to outweigh the potential risk that can be remedied. Quantitative population

studies are needed to provide evidence of the benefits and health impacts versus potential harms from community gardens.

Keywords Community gardens · Soil toxicants · Environment · Developing countries · Urban · Chronic diseases · Nutrition

Introduction

A community garden is a plot of land gardened collectively by a group of people who are living in an urban area. It is different from a private garden on the property of an owner, or a community farm that is more focused on larger agricultural production and economically driven. According to the American Community Garden Association, a community garden is somewhere that people come together to grow plants and share the benefits of doing so. Although there is a sense of individual ownership, independence, and pride over produce, community gardens tend to encourage ethnocentric ways of thinking where people with different ethnic, religious, and cultural background interact and form a community [1, 2]. Often these gardens involve people that are part of a certain community or locality but can also include unrelated diverse individuals from different neighborhoods.

The inclusive nature of community gardens has been attributed to bringing communities together, and they are becoming increasingly widespread in more developed countries, especially the USA. The history of use of community gardens dates back to the beginning of the last century when they were called the War Gardens or Victory Gardens to support the war effort that peaked in 1944 when 40% of fruits and vegetables consumed in the USA were grown in community gardens [3–6]. More recent use of community gardens in the past few decades

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has been associated with preserving the environment and having access to fresh and organic food not readily available in urban settings [7, 8], but also as a result of the economic crises in the 1970s [9], and more recently the economic downturn in 2008 which resulted in a 19% increase in community gardens in the USA [5]. However, an often neglected impact of community gardens is its improvement of the health and well-being of the users [9]. This can be through greater access to healthy foods, increased physical activity, and, in less developed countries and some low-income populations in the developed countries, gardening projects can address food security. In the age of chronic diseases, community gardening intervention programs could be an important solution for addressing the common risk factors of chronic diseases such as diabetes and cardiovascular diseases as participation encourages healthy behaviors.

The apparent popularity of community gardens and their potential benefits have encouraged many governments and city councils to allocate specific spaces for community gardens [3]. Some of the topics that have been discussed in current literature regarding community gardens include health behaviors, food security, community cohesion, social capital, and physiological but also some risks of contamination. While there is qualitative research exploring such themes, there are limited quantitative population studies.

The purpose of this review was to summarize current findings on community gardens relevant to three specific areas of interest: (1) health benefits, (2) garden interventions in developing versus developed countries, and (3) the concerns and risks of community gardening. This review also highlights the need for further studies by public health researchers to quantify the impact of this environmental health intervention on communities, in particular the potential benefits of community gardens in communities affected by health disparities. The studies cited in this review are arranged in Table 1 to summarize the findings and for comparison purposes.

Health Benefits

Chronic Diseases

Within the last few decades, chronic diseases such as type 2 diabetes, obesity, and heart disease have been on a steady incline all over the world. According to the US Centers for Disease Control and Prevention [43], obesity rates have more than doubled or tripled since 1980 with 34.9% of people in the USA being considered obese, and these rates are higher in children and adolescents. Those overweight children are at high risk of type 2 diabetes and other complications. The primary behaviors that are causing these health complications are well known and easily preventable, as are the behaviors that could help avoid them. For example, more than 50% of American adults do not get the daily recommend amount of physical activity, and

despite it being well known that fruit and vegetable consumption reduces chronic disease risk, only 25% of American adults meet current consumption recommendations [43].

Although individual factors are important in combating these health issues, in recent years, there has been an increased shift towards focusing on environmental determinants of health behaviors, such as the built environment or availability of fresh fruits and vegetables by addressing “food deserts” in low-income communities [7, 8]. Developing community gardens is a notable strategy that has been gaining particular attention as an environmental intervention that can improve the health of both the community and the individual [9]. A community garden would encourage residents to walk, be physically engaged in gardening activities, learn about healthy food, and consume such healthy food (Table 1). As demonstrated in the following sections, community gardens can be considered as a single environmental intervention that can simultaneously address risk factors for diabetes, cardiovascular diseases, and cancer.

There is also data suggesting that community gardens have a measurable positive impact on individuals with mental health conditions and provides biopsychosocial-spiritual well-being, but more quantitative data is needed to support those findings [44–46]. The impact of gardens and greenery extends to children and adults by improving attention and memory as well as future cognitive function of elderly [47]. More research is needed to document such impacts from working in community gardens regarding specific mental illnesses.

Access to and Consumption of Fruit and Vegetables

One health behavior that has received much attention in community garden literature is the consumption of fruits and vegetables. A population-based telephone survey of 776 participants in Flint, Michigan, assessed respondent’s perceptions of their food environment. Although a small percentage of 15% reported that they, or a member of their household, partook in community gardening, 34% of those respondents in gardening households consumed fruit and vegetables at least five times a day, in comparison to 17.8% of those from non-gardening households [10]. Other studies on urban gardens have produced similar supportive findings of healthier food consumption, such as Litt et al. [25] in Denver, Colorado; Twiss et al. in Los Angeles, California [35]; and Blair et al. in Philadelphia, Pennsylvania [13]. These benefits are not limited to urban environments and are also present in rural communities. In rural Missouri, a study revealed that 95% of the gardeners reported more than a twofold increase in the likelihood of meeting daily recommendations of fruit and vegetables as compared to those not reporting any community garden participation [12].

All literature available on fruit and vegetable consumption among community gardeners clearly indicates the higher preference and consumption of fruit and vegetables among the

Table 1 List of articles that focus on community gardens and the description of their population, study settings, and results

Reference	Population	Setting	Type and method	Results
Alaimo et al. [10•]	African Americans (38.5%) Caucasian (61.5%) N = 766	Flint, Michigan	Intervention study, quantitative	<ul style="list-style-type: none"> • Individuals from gardening households reported greater consumption of fruits and vegetables than those respondents whom did not come from gardening households
Alaimo et al. [11]	Adults (N = 1916)	Flint, Michigan	Case study, qualitative, telephone-based survey	<ul style="list-style-type: none"> • There is an association between participation in community gardening/beautification projects and neighborhood meetings with perceptions of social capital at both the individual and neighborhood levels
Barnidge et al. [12•]	Populations-based survey (N = 1000) Convenience sample (N = 141) Caucasian (67.4%), African American (34.8%), other	Missouri, rural	Case study, population-based sample, qualitative	<ul style="list-style-type: none"> • Two complimentary studies provide evidence that community gardens are a promising strategy for promoting fruit and vegetable consumption in rural communities
Blair et al. [13]	144 community gardeners 67 non-gardeners	Philadelphia, Pennsylvania	Case control	<ul style="list-style-type: none"> • Community gardeners consumed several vegetables more often than their non-gardening counterparts • Community gardeners were less likely to consume dairy products, citrus fruits, baked goods, and soft drinks than non-gardeners
Castro et al. [14]	Latino youth (2–15 years) N = 95	North Carolina	Intervention, quantitative	<ul style="list-style-type: none"> • Community garden intervention helped children improve unhealthy BMIs, maintain Healthy BMIs, and increased the availability and consumption of fruit and vegetables among the children
Clarke et al. [15]	12 gardens	Los Angeles, California	Case study, quantitative	<ul style="list-style-type: none"> • High levels of Pb, As, and Cd found to be present in soil of community gardens
Dadvand et al. [16]	2593 schoolchildren (age 7–10) 36 primary schools	Barcelona, Spain	Case study, quantitative	<ul style="list-style-type: none"> • Beneficial association between exposure to green spaces and cognitive development among schoolchildren. This is partially mediated by reduced exposure to air pollution (20–65%).
Eizenberg [17]	Community gardeners	New York City	Case study	<ul style="list-style-type: none"> • Mechanism of participation depends on community control and a sense of ownership in the creation of a successful community garden
Faber et al. [18]	Experimental: 107 children (2–5), 97 households Control: 58 children (2–5), 48 households	Ndunakazi, rural South Africa	Intervention study, quantitative	<ul style="list-style-type: none"> • Positive correlation found between consumption of yellow and dark-green leafy vegetables and serum retinal concentrations in children • Also improved vitamin A status of 2–5-year-old children
Gallaher et al. [19]	306 households Farmers (N = 153) Non-farmers (N = 153)	Nairobi, Kibera Slums, Kenya	Case study, qualitative	<ul style="list-style-type: none"> • Litter and biological contaminants attributed to soil contamination in the slums so many people practice sacking gardens
Gatto et al. [20••]	Latino children: fourth and fifth grade (9.8 ± 0.7 years) N = 104 Control subjects: N = 70 Sprouts participants: N = 34 59.8% overweight or obese	Los Angeles, California	Intervention, qualitative and quantitative	<ul style="list-style-type: none"> • A cooking, nutrition, and gardening after school program in a garden-based setting can improve attitudes and preferences for fruits and vegetables in Latino youth • The overweight subgroup showed a greater increase in their preferences for vegetables compared to the control group
Ghosh-Dastidar et al. [8]	16 stores 1372 primary household food shoppers	Pittsburgh, Pennsylvania	Case study, quantitative	<ul style="list-style-type: none"> • Supermarkets in food deserts have little effect on healthy eating if healthy food is not made more affordable at the same time
Glover [1]		Midwestern USA, urban	Case study, qualitative	

Table 1 (continued)

Reference	Population	Setting	Type and method	Results
Hanna and Oh [21]	14 members of neighborhood association Caucasian, African American, and Latino (Majority Caucasian) Adult community gardeners—African American (57%), Caucasian, and Asian (N = 44) 44 community gardeners African humanitarian migrants	West Philadelphia, urban	Case study, qualitative	<ul style="list-style-type: none"> Community gardens encourage the mobilization of neighborhoods and collective efficacy Community gardens provided fresh produce to consume, donate, and sell The gardens improved physical activity, reconnected participants with the earth, and gave a sense of community Community gardens can connect immigrants to their host country by encouraging a perceived link between plot tenure and participation in the community with becoming a citizen Working the land is a familiar and purposeful activity Individuals gardening on such sites may be unaware of the risk to exposure and how to manage them Need for clear and concise information on how to best prevent and manage soil prevention and the risks of it Community gardens have many well-being benefits as members identified spiritual, fitness, and nutritional benefits from participation (especially spiritual) Success of community gardens and more people eating fruit and vegetables was very reliant on strong neighborhood leadership, outreach, and volunteerism (higher social involvement) This study suggest that community gardening programs may not be effective options for some families to improve their access to food due to reliance on wages and not enough free time High levels of heavy metals with in community garden soils may be a result of historical human activities Food gardening tends to be associated with survival rather than affluence, and constraint rather than choice Gardening associated with old-fashioned lifestyle and younger generations do not become involved in it High levels of heavy metals found within Asian rice sold in Iranian stores Exposure to such heavy metals could be very dangerous for one's health, being associated with anemia, hypertension, and serious effects on the kidneys, lungs, and bones CCA-treated wood contaminates surrounding soils. Crops grown in contaminated soils showed higher levels of As (although the levels of As did not surpass the US recommended levels) Community service projects improve at risk youths attitudes towards community—promoting personal, social, and intellectual growth among participants
Harris et al. [22]		Logan City, Queensland, Australia, urban	Case study, qualitative	
Kim et al. [23]	15 gardens Adult community gardeners (N = 70)	Baltimore, Maryland, urban	Case study, qualitative	
Kingsley et al. [24]	Adult community gardeners (N = 10)	Port Melbourne, Australia, urban	Case study, qualitative	
Litt et al. [25]	Telephone survey: adults (N = 436) List survey: 13 gardens, adult gardeners (N = 300)	Denver, Colorado, urban	Case study, qualitative	
Loopstra and Tarasuk [26]	371 families	Canada	Case study, qualitative	
Mitchell et al. [27]	53 gardens	New York City, urban	Case study, quantitative	
Møller [28]	NA	Eastern Cape Province, South Africa, rural	Case study	
Naseri et al. [29]	NA	Iran	Case study, quantitative	
Rahman et al. [30]	NA	NA	Case study, quantitative	
Sandler et al. [31]	Native American youths, Yaqui (N = 13)	Arizona Sonoran desert, rural	Case study, qualitative	

Table 1 (continued)

Reference	Population	Setting	Type and method	Results
Shisanya and Hendriks [32]	53 households	Maphephetheni Uplands, South Africa, rural	Case study, qualitative	<ul style="list-style-type: none"> • Although community gardens do not massively contribute to food insecurity, their contribution to consumption cannot be ignored
Sommerfeld et al. [33]	Adults ($N = 298$)	USA	Case study, qualitative	<ul style="list-style-type: none"> • A questionnaire based on the Life Satisfaction Inventory A (LSIA) suggested that overall life satisfaction scores among gardeners were higher when compared to non-gardeners, e.g., higher perception of health
Mitchell et al. [27]	NA	New York City	Case study, quantitative	<ul style="list-style-type: none"> • Chicken eggs in community gardens known to have contaminated soil were found to have higher levels of Pb than those sold in stores and those analyzed in a similar study in rural Belgium
Teig et al. [34]	67 adult community gardeners 29 gardens	Denver, Colorado	Case study, qualitative	<ul style="list-style-type: none"> • The social organization of gardens gives rise to a number of social processes such as social networks, mutual trust, collective decision-making, civic engagement, and stronger neighborhoods
Twiss et al. [35]	6 California healthy city and community projects	California, USA	Case study	<ul style="list-style-type: none"> • Community improvements from gardening projects are very varied, from increased knowledge to behavioral changes • Differences demonstrate the importance of integrating community gardening into development
Wakefield et al. [36]	Adult community gardeners ($N = 55$)	Toronto, Canada, urban	Case study, qualitative	<ul style="list-style-type: none"> • Gardeners perceived a number of health benefits such as access to food, improved nutrition, improved mental health increased physical activity, and consumption of more fruit and vegetable
Ward et al. [37]	Women ($N =$ unknown)	Mali, rural	Case study, qualitative	<ul style="list-style-type: none"> • NGOs and community members have diverging ideas about the purpose of the gardens (food security versus commercial opportunity) • Can empower women but target population must have control over the project in order to be successful
Weltin [38••]	Marshallese immigrant women ($N = 17$)	Dubuque, Iowa	Intervention, quantitative	<ul style="list-style-type: none"> • Glycated hemoglobin levels improved from 8.2 to 6.6% among garden participants • Study provides an insight into cultural limitations (gardening was not socially acceptable for men)
Williams [39]	NA	Washington DC, urban	Case study, qualitative	<ul style="list-style-type: none"> • Road proximity increases the risk of contamination as impervious surfaces do not filter rainwater like wetlands do
Williams et al. [40]	NA	Haiti	Case study, qualitative	<ul style="list-style-type: none"> • Establishing community gardens in post-earthquake Haiti is being encouraged as viewed as a way by which to alleviate food insecurity as NGOs and charities reduce the amount of food aid
Zick et al. [41••]	Adult community gardeners ($N = 198$)	Salt Lake City, Utah	Case study, quantitative	<ul style="list-style-type: none"> • Men and women involved in community gardens had a significantly lower BMI than 7 their neighbors and siblings and less chance of being overweight
Zoellner et al. [42]	Youth ($N = 87$) Parents ($N = 67$)	Dan River region of South Virginia, north-central and North Carolina	Case study, qualitative	<ul style="list-style-type: none"> • Benefits of community gardens increase community cohesion and improved nutritional and physical activities • Parents attitudes, belief, and self efficacy above average but gardening intentions neutral

gardeners as opposed to non-gardeners. However, we did not identify any intervention-based studies with quantifiable results exploring this health behavior. Such research could confirm whether it is the involvement in the community gardens that increases consumption of fruit and vegetables or independent individual lifestyle preference that leads more of the people who consume fruits and vegetables to work in community gardens.

Physical Exertion

Increased exercise is also a health behavior that is notably higher among community gardeners. Although there is literature available on physical activity, it is limited to feelings of physical fitness and there are no studies examining the quantifiable effects of community gardening on this health behavior [24, 36]. However, the association of community gardens with good physical fitness has encouraged people to join community gardening projects solely on the expectation of improved fitness [24]. Moreover, gardeners have been shown to rate their physical health as better and many listed increased exercise in the garden as being responsible for this [33, 35]. It was found that adults age 50 years or above who did not participate in gardening were three times more likely to consider themselves “quite inactive” compared to gardeners, while the gardeners were almost twofold more likely to report being “quite active” and report better health [35], which was consistent with other findings showing positive impact of gardening on physical activity [25, 48].

Physiological Impacts

But do these behaviors have long-term quantifiable health benefits? Some research has been carried out to discover the physiological benefits of gardening in community settings, with numerous studies reporting back positive physiological impacts. Studies that use quantifiable data support the common perception of community gardeners that their physiological health is better than before they began gardening and superior to non-gardeners [33]. A population-based study in Salt Lake City showed community gardeners to have significantly lower body mass indexes (BMIs) than their neighbors and siblings and a lesser chance of being overweight in a cross-sectional study using the Utah population database [41••]. On average, female gardeners had a BMI 1.48 times lower than their neighbors and male gardeners had a BMI 2.52 times lower than their neighbors. Between siblings, women involved in the gardens had a BMI 1.88 times lower than their sisters and men had a BMI 1.33 times lower than their brothers [41••].

A 6-month intervention study conducted in Iowa among Marshallese immigrants suggested that community gardening could be used to combat chronic health conditions such as type 2 diabetes. By the end of the intervention, glycated

hemoglobin levels among diabetics had improved from 8.2 to 6.6% among participants, while the non-participating diabetic control group experienced worsening glycated hemoglobin levels from 9.3 to 9.9% [38••].

These studies suggest the potential of community gardens to address chronic diseases by improving physiological health indicators of these diseases.

Studies of Children

Much of the literature on community gardening and health behaviors is dedicated to studies on adolescents and children. Studies with adolescents and children have generally been similar to adult results in terms of health behaviors. A 7-week intervention involving nutrition, cooking, and gardening study among obese children in North Carolina showed that community gardening led to 17% of obese or overweight children to improve their BMI and the children with normal BMIs pre-intervention did not increase in weight and maintained their normal BMI after the intervention [14].

A study of a children’s summer camp found that a total of 63% ($n = 87$) of the children involved in the camp garden, who were generally low income, reported that they would be willing to try new fruits and 73% answered positively for trying new vegetables [42]. Both the parents and the children attributed this higher level of interested in nutrition to participation in the summer camp garden.

The “LA Sprouts” study consisted of a 12-week cooking, nutrition, and gardening after school program in a garden-based setting in Los Angeles among Latino youth aged 9–11 years supports the above findings [20••]. Surveys taken pre- and post-intervention with both the children participating in the LA Sprouts program and those not found that within the overweight/obese subgroup, Sprouts participants had a 16% increase in their preference for fruit and vegetables compared with the control youth who did not receive the LA Sprouts intervention [20••]. Other health benefits of having green space in the environment of children were associated with better attention and improved cognitive function [16].

Although these studies are useful, there is a need for research that would engage the adult members of communities as well as their children, as the success of the gardens is reliant on higher social involvement and leadership from parents [49].

Developing Versus Developed Countries

The available literature on community gardening projects demonstrates some differences in the reasons that community gardens exist in developing countries versus developed countries. Within developed nations, most studies approach the community garden as a feasible way of improving livelihood, social capital, and physiological health in the era of

community disengagement and excess of unhealthy food and chronic diseases. On the other hand, a recurring theme of why community gardens are established in developing nations is to address food insecurity. Around 9 million people will die a year from malnutrition, and these community gardens are seen as a way of combating this issue by making food more accessible in areas where people lack the resources to feed themselves properly [40]. This is in contrast to developed nations where the gardens act as an incentive to eat less processed, highly calorific foods, and eat more fresh produce with less preservatives and calories [7, 8].

Food Security

Food security is defined by the US Department of Agriculture as “high food security” when there is no indication of food access problems or limitations and “marginal food security” when there is some worry about food sufficiency but no changes in food intake. Community gardens have been employed as a technique to rejuvenate the earthquake devastated Haiti since 2010 by USAID to provide food security [40]. Many charities and NGOs have begun to reduce the amount of food aid provided to the country, despite high rates of poverty. USAID have attempted to work with locals to establish a secure agricultural system by educating people on modern farming techniques and by providing financial, commodity, and institutional backing for a community garden system [40]. Projects like this are aimed at combating hunger to return stability and sustainability to the lives of many in Haiti.

Despite these good intentions in developing nations, much research would suggest that community gardens have nominal success in alleviating food insecurity. Firstly, for the youth of the developing world whom aspire to a modern lifestyle, gardening is associated more with survival than affluence and is thus stigmatized as such. These views were very common among South African youths, whom appeared to be more interested in following Western lifestyles than practicing old fashion gardening in a survey from rural Eastern Cape Province in South Africa [28]. Two other South African studies had conflicting conclusions about gardening for food security, where one found little evidence to alleviate food insecurity because there was not good agricultural practices and the authors recommended agricultural and nutritional advice to overcome food insecurity [32], while another found an increase consumption of healthy fruits and vegetables because gardening was associated with community-based nutrition education [18].

In developed nations, similar projects seem to have taken findings like these into consideration and offer nutritional educational packages in target areas, of which both physical gardening and agricultural and nutritional advice are a part of. The LA Sprouts’ work [20••] follows such a structure with schoolchildren in Los Angeles using a cooking, nutrition, and

gardening after school program to improve attitudes and preferences for healthy foods among low-income and obese youth.

Further research into food security has revealed that diverging ideas between NGOs and community members about the purposes of the gardens has limited their success. For instance, in Ouelessebouyou, Mali, the NGO’s focus on food security hindered the success of the gardens, as participants saw the projects more as an opportunity for commercial gain in a time of economic struggle [37]. The importance of recognizing the needs of participants and tailoring garden projects to their needs is crucial for the success of community garden projects. In New York, in a capitalist space-searching market, two mechanisms of managing community gardens were compared. The mechanism of participation depended on community control and a sense of ownership in the creation of successful community gardens [17]. The *Trust for Public Land* model was the more successful model at achieving this by focusing on community ownership and the most active gardens compared to the model of the *New York Restoration Project* that focused on the preservation of land and designing the gardens without input or involvement from the gardeners themselves [17].

The final factor to consider in why the food security promised by some community garden projects may not come to fruition is economic restriction. These restrictions are not unique to developed or developing nations. A study on the feasibility of community garden projects among low-income families in Toronto revealed that these programs may not be an effective option for some families to improve their access to food, as reliance on wages means that participants may not have enough time to invest in the garden in order to reap its rewards [26]. Earlier studies, however, have found community garden a good source of food security for low-income urban communities [50]. There needs to be a more comprehensive economics studies about the financial benefits for the different community garden models.

Research in developing nations suggests that community gardens have the capacity to improve food security, and this could be of much value for programs trying to encourage healthy nutritious lifestyles in lower-income neighborhoods in developed counters. However, as these studies have shown, there are a number of barriers to overcome when devising a success strategy for community involvement. The encouragement of youth participation, nutrition education, the amount of power the participants have over the programs, the division of labor, and economic restrictions are all important factors to consider when implementing a community garden as part of a nutrition program.

Empowerment

Empowerment in the sense of community gardens reflects opportunity and motivation to take an active role and authority over issues of relevance to the individual and community. These lead to promoting social, health, and environmental

change [5]. Research from Mali has shown that the significance community gardens could play in female empowerment [37]. Women in Ouelessebouyou, Mali, increased their purchasing power through gardening and have managed to maintain a certain level of control over their income. In 2004, it was estimated that 78% of economically active women in Mali were engaged in agricultural activities [37]. Since the onset of World War I, community gardens have been seen as a way of elevating poverty and building social capital as they provide fresh produce not only for consumption but also for sale [5, 6]. Although most studies indicate that people partake in such gardening projects for pleasure, a study in West Philadelphia identified urban community garden and farm participants that sold their produce, such as berries, to local restaurants [21]. In most US cities, selling produce from community gardens would require approval by the US Department of Agriculture (USDA), but these regulations vary by state and by sources of the products being from a residential private garden or community garden, and if production for human consumption is less than \$500,000 over the past 30 years, there is exemption from oversight of selling produce from gardens or farms [51]. Further, selling as USDA-certified organic produce requires other verification and certification by specific agencies and entities [52].

It should also be noted that empowerment goes beyond one's power over their income and can refer to the participation in an active community. Such participation demands a degree of responsibility, and literature suggests that empowerment through community is a common benefit of community gardening as it encourages active engagement, teamwork, and leadership in efforts to reach collective goals [1]. All the above descriptions of empowerment have indirect positive health impacts on the physical and mental well-being of those partaking in community gardens [53, 54].

On the other hand, some studies have indicated that community gardens do little to empower men as many choose to not be involved in the garden programs. In Mali, men refused involvement as they saw gardening as a woman's activity [37]. This is similar to attitudes among Marshallese refugees in Iowa whom considered gardening to be a socially unacceptable activity for men [38••]. Further research could look into how projects could better involve men and create environments within which it would be more socially acceptable for them to participate in gardening.

Social Cohesion

In developed nations, community gardens are typically associated with improving community mobilization and increasing community pride. A Canadian survey on gardens explained how pride is affected at an individual level as participants expressed satisfaction at their involvement and a feeling of empowerment by improving their skills [36]. Moreover, gardening projects with young people in schools have shown

increased student engagement and confidence among those participating [42]. At the community level, participants enjoyed working together to achieve a beautiful environment, feeling fulfillment when passersby notice the greenery of the gardens, and collectively meeting higher perceptions of social capital [11]. Participating in community gardens lead to trust, civic engagement, leadership, and social connections that help in community building [34].

The apparent success of using community gardens to increase social cohesion and a sense of belonging has been applied to programs integrating immigrants and other high-risk groups into their physical and social environments in developed countries. Sandler et al. [31] reported success when using a gardening program to reconnect Native American Yaqui youths to their culture over the course of a 10-week workshop. Many similar studies that have been conducted indicate that the gardens are important meeting places for people to connect with others like themselves [21].

Research on immigrant integration projects reveal that community gardens are particularly important for connecting immigrants to their host country. This could be because there is a perceived link between plot tenure and participation in the community with becoming a citizen [22]. Furthermore, immigrants from developing countries with a large economic focus on agriculture may stand to benefit even more from integration programs involving gardening as gardening not only connects them to the land but also serves as a familiar and purposeful activity of growing and selling their own crops.

The impact on social cohesion is an interesting and relevant new focus for research conducted on the effects of community gardening that could yield important results, which could aid the development of community garden programs. However, so far, this approach to community gardening has received little attention. Research is needed to expand our understandings of the effectiveness of gardening in community integration, for instance among migrants. The impact on social cohesion could be studied in many different scenarios, especially in the light of the current refugee crisis in Europe.

Social cohesion, integration for new immigrants, and civil engagement are powerful factors for the improved mental well-being of communities that are on the fringe of society or living an individualized and socially isolated lifestyle [5, 55–57]. There is limited understanding on the association of social cohesion with community gardens in the less developed countries.

Concerns and Risks of Community Gardens

Plot Contamination and Causes

Over the last decade, concerns over community garden contamination have gradually increased and a large number of

studies have been carried out testing the levels of toxicants such as heavy metals in soil of plots. Much of this research has focused on urban gardens, because they have greater exposure to more contaminated dust in the environment or because they were previously used for purposes that led to its contamination with toxicants, what is known as brownfields, and then converted to community gardens [15, 58–60]. A Los Angeles survey of 12 different community gardens within the city supports concerns of contaminated soils in urban gardens [15]. The study suggested that high concentrations of heavy metals such as lead (Pb), arsenic (As), and cadmium (Cd) are present in urban community gardens.

Similar studies in other cities and urban environments have produced similar results; in 53 New York City community gardens, high levels of lead and other contaminants were found as a result of historical human activities, including waste incineration, coal and oil combustion, the use of leaded gasoline, paints containing lead and other metals, and demolition of old housing [27]. Neighborhoods where these activities have occurred are more likely to have higher levels of contamination, and thus expose their residents to such harmful toxicants. These neighborhoods are typically low-income communities and can be situated in high-risk areas, such as within close proximity to highways and freeways or contaminated sites [61–63]. Road proximity increases the risk of contamination because their impervious surfaces do not filter rainwater as wetlands do and the rainwater will run off the roads into the surrounding soils and waterways, carrying with it acid, oil, grease, and heavy metals [39].

Many community garden-based nutrition programs are situated in such neighborhoods and are commonly built on vacant lots with historically elevated levels of contamination, such as old parking lots and sites where poor housing has deteriorated and was demolished [64, 65]. It is therefore important to monitor toxicant levels in the soil and produce to make sure that they are not at harmful levels.

Risk of Soil Contamination for Gardeners

Important questions are whether these higher levels of contamination represent a risk for the health of those who work the land and eat the produce in these community gardens? There has not been much research on this matter to try and link community garden produce or working within such gardens with personal levels of exposure, even though evidence suggests that produce grown in such contaminated environments may contain some of the harmful toxicants from the soil [66, 67] (see Table 2). Lead and arsenic are the most common contaminants cited as the source of toxicants, and root vegetables and green leafy vegetables are generally considered as more prone to absorb and store contaminants from contaminated soil.

Other sources of contamination include eggs from chicken feeding from contaminated soil. A study in New York City community gardens looked at the concentration of lead in eggs from community garden chicken. It is common for chickens to eat soil in order to obtain the calcium and other minerals needed for making egg shells; this means that they may ingest harmful chemicals as well [68]. The study found that a soil-to-egg transfer of contaminants as lead was detected in 44% of the eggs. Many eggs also had over 100 µg/kg of lead. It has been shown that eating such contaminated eggs can exceed or approach the threshold of daily lead intake from all sources [69, 70]. In comparison, store brought eggs have far lower levels of lead. Findings such as these increase concerns of the risks of community gardens; however, it should be noted that some store brought products, have high levels of toxic materials, and thus “store” status does not guarantee less contamination within food.

Heavy metals have been associated with anemia, hypertension, and may have serious effect on the kidneys, lungs, bones, and the cardiovascular system [29]. Although rice is not grown in community gardens, it is presented here as an example of contamination through uptake from land by edible plants, where recent findings demonstrate high arsenic levels in US-grown rice [71]. Therefore, this risk from a common staple to many immigrant populations to the USA is not limited to imported rice. This has led to recommendations against feeding rice baby formulas to infants [72]. However, there is yet to be a study to quantify the levels and effects of exposure of toxicants within urban community gardens from different edible plants. The type of plants grown in a presumably contaminated community garden can determine the potential exposure levels, but other factors of quantity of eating from garden produce and individual variation in processing toxicants in the human body will play a role (see Table 2 for more details regarding the example of arsenic contamination in vegetables).

Community Concerns

People will frequently make connections between the quality of their local environments and risks to their health. For community gardeners, concerns of local environment and its impact on the food from the garden typically extend to visible contamination such as open sewage and litter [19]. However, one increasingly growing concern is the quality of the soil and water sources within community gardens. There is a fear that toxic substances within the soil and water, such as heavy metals, may be absorbed by the plants and livestock, and thus could be consumed by participants via the produce as well as some animal products.

Current literature gives mixed feedback on the concerns of community gardeners with regards to such risks, with some reporting high awareness and concern and others claiming that participants have little concern and a lack of information on

Table 2 Arsenic uptake levels from contaminated soil by vegetable categories arranged from the least to the most to uptake arsenic from soil

Type of vegetable	Highest level of arsenic in garden samples	Range of arsenic from the literature
<i>Solanaceae</i> plant family	Not correlated to soil arsenic levels	0.021–0.91 mg arsenic per kg
Tomato	0.07 mg arsenic per kg	
Jalapeno	0.07 mg arsenic per kg	
Bell pepper	0.08 mg arsenic per kg	
Green chili	0.08 mg arsenic per kg	
<i>Curcubitaceae</i> plant family	Not correlated to soil arsenic levels	0.05–0.61 mg arsenic per kg
Delicate squash	0.02 mg arsenic per kg	
White squash	0.02 mg arsenic per kg	
Cucumber	0.08 mg arsenic per kg	
Spaghetti squash	0.08 mg arsenic per kg	
Zucchini	0.17 mg arsenic per kg	
Yellow squash	0.28 mg arsenic per kg	
<i>Fabaceae</i> plant family	Moderately correlated to soil arsenic, $r^2 = 0.56$	0.096–1.72 mg arsenic per kg
Bean	0.39 mg arsenic per kg	
<i>Amaranthaceae</i> plant family	Highly correlated to soil arsenic, $r^2 = 0.86$	0.1–13.0 mg arsenic per kg
Beets	0.06 mg arsenic per kg	
Amaranth	0.18 mg arsenic per kg	
Spinach	0.55 mg arsenic per kg	
Swiss chard	1.27 mg arsenic per kg	
Beet fruit	1.44 mg arsenic per kg	
<i>Liliaceae</i> plant family	Weakly correlated to soil arsenic, $r^2 = 0.14$	0.13 mg arsenic per kg
Garlic	0.18 mg arsenic per kg	
Chives	0.21 mg arsenic per kg	
Onions	1.97 mg arsenic per kg	
<i>Brassicaceae</i> plant family	Highly correlated to soil arsenic, $r^2 = 0.87$	0.09–80 arsenic per kg (highest levels in the literature)
Cabbage	0.06 mg arsenic per kg	
Broccoli	0.11 mg arsenic per kg	
Brussels sprouts	0.17 mg arsenic per kg	
Radish fruit	0.20 mg arsenic per kg (showed second highest uptake of arsenic in experimental setting)	
Red cabbage	0.31 mg arsenic per kg	
Kale	0.56 mg arsenic per kg	
<i>Asteraceae</i> plant family	Highly correlated to soil arsenic, $r^2 = 0.79$	0.08–34.9 arsenic per kg
Lettuce	0.48 mg arsenic per kg (showed highest uptake of arsenic in experimental setting)	

The corresponding measured soil arsenic levels varied for the different vegetables. Adapted from Ramirez-Andreotta MD, et al. *Sci Total Environ.* 2013;443:299–306, with permission from Elsevier [66••]

contamination. For example, in a study conducted in Toronto, participants believed that growing fruits and vegetables in contaminated soil is the most significant risk associated with community gardening [36]. Concerns were also raised over air pollution in urban environments. On the other hand, a survey on the knowledge and perceptions on risks among 70

community gardeners in Baltimore [23] found that individual gardeners on such sites are often unaware of the risks of the exposure to toxic substances in the soil and produce and felt that using raised beds would protect them from any contamination. With the increase in community gardens, soil contamination is becoming a key concern for community gardeners.

Protective Measures

As community concerns increase, so do active efforts to reduce risks. The types of measures taken to reduce toxic substances in the soil of urban community gardens and prevent transfer of toxicants include raised beds, top soils, the use of untreated wood, and regular testing. These are added costs and burden regarding the start of community gardens. Limited literature is available on this topic; however, the few studies that have taken place suggest that education is key to encouraging the mobilization of communities on the matter of garden plot contamination. For example, in the Kibera Slums in Nairobi, residents avoid using community plots out of fear of contamination and practice sacking gardens [19]. Sacking gardens are hanging gardens made out of sacks used to grow produce. However, in such cases, only litter and other visible biological contaminants are attributed to soil contamination as residents have not been educated on the dangers of high levels of heavy metals within the soil which is used in both the plots and the sacking gardens. This demonstrates a disparity between real and perceived risks and shows the need for informed health risks within high-risk communities.

A common example of gardeners being unaware of risks is the use of copper chromate arsenate (CCA) wood in creating the raised soil beds. It has been proven that arsenic, copper, and chromium diffuse into the surrounding soil from CCA-treated wood, which could be harmful for people who consume the produce grown in that soil [30, 73, 74]. In light of the new trend of using old railway sleepers (which are often treated with harmful chemicals and contain tar) to make raised beds, this could be a significant hazard. Rahman et al. [30] grew carrots, spinach, bush beans, and buck wheat in soil samples taken 0–2 cm away from the CCA-treated wood. All the crops grown in contaminated soil had higher levels of arsenic than crops grown

1.5 m away from the wood. Although the levels of arsenic in the crops did not surpass the recommend limit for arsenic set by the US public health sector (2.6 mg kg), this finding still highlights the risks posed by misguidance about protective gardening practice and further supports the need for clear and concise information on how to prevent and manage soil contamination as well as the risks it poses to human health [30]. In Table 3, we outline the benefits and risk of community gardens.

Conclusion

Community gardens are becoming increasingly relevant as a means to support social cohesion and integration and provide health benefits. The abundance of mostly descriptive literature, especially within recent years, reflects the recognition of the importance of community gardening. Although available literature is mostly qualitative data, it is clear that gardening is associated with health benefits by actively encouraging healthy behaviors such as fruit and vegetable consumption and more physical exercise. These findings suggest a promising new technique for addressing chronic disease by focusing on multiple risk factors through engagement of community gardens.

However, studies have shown that community gardening is not without risk and that participants might become exposed to heavy metals and other chemicals present at certain contaminated plot sites. A number of rigorous quantitative tests of soil contamination levels suggest that community gardeners are not putting themselves at serious risk by working in contaminated plots. Nonetheless, participants in community gardens should be made aware of the potential risks of gardening at such sites; there should be monitoring of metals, and the evaluation of potential interventions.

Table 3 Benefits and risks of community gardens

Potential benefits	Potential risks and solutions
1. Physical activity	1. Exposure to toxic soil contaminants from gardening
2. Improved diet	<i>Solution: wear protective gloves and follow protective practice</i>
3. Education about healthy food	2. Exposure to ingestion of pollutants and toxic substances from produce of heavily contaminated community gardens
4. Improved physiological indicators	<i>Solution: sample soil for toxicant levels and select fruit trees or vegetables that are least likely to uptake toxicants. Use raised soil beds</i>
5. Improved well-being and mental health	3. Introducing toxic substances from poor gardening practice
6. Improved cognitive function of the elderly	<i>Solution: use organic fertilizers and products and not use chemically treated wood in the garden</i>
7. Social cohesion	4. Raising domestic animals that become another source of contamination
8. Integration of new immigrants into society	<i>Solution: limit the animals to areas and food sources with no contaminants</i>
9. Empowerment	
10. Food security and an additional source of income	

Although currently limited, there are a number of articles discussing community gardens in the developing world. These studies provide useful results that may help in the creation of more successful intervention gardening programs by allowing for a different perspective on what should be achieved by a community garden. We summarize the benefits versus risks of engaging in community gardens for production of edible produce. Awareness about the risk is important for planning purposes including learning about the history of the land to be used for a garden, and sampling soil for analyses where possible. This might help make better decisions with regards to growing a community garden in a specific location.

In order to advance this field and inform the public and local governments, quantitative studies and quasi-experimental community interventions are needed to provide much needed evidence and fill in the gap regarding the human health impacts from community gardens. The introduction of community gardens to neighborhoods of disadvantaged communities that need it the most, coupled with toxicological studies of plants and soil, would be needed to document the health benefits versus risks. Funding for such studies can provide the much needed evidence. Further, there is sparse data on the impact of community gardens in less developed countries with different social, economic, and health perspectives than the developed countries. However, this limitation in evidence should not discourage the establishment of more community gardens globally to address food insecurity, provide health benefits, and create communities that work with each other on social issues that extend beyond the community garden.

Compliance with Ethical Standards

Conflict of Interest W.K. Al-Delaimy and M. Webb declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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