ORIGINAL RESEARCH

CURRENT DEVELOPMENTS IN NUTRITION

Community and Global Nutrition

Strengthening Vegetable Production and Consumption in a Kenyan Informal Settlement: A Feasibility and Preliminary Impact Assessment of a Sack Garden Intervention

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ABSTRACT

Background: Over 85% of Kibera's population, an informal settlement in Nairobi, Kenya, is food insecure. Nutrition-sensitive agriculture interventions, such as sack gardens, have the potential to diversify diets—in turn, improving household food security and diet quality. Furthermore, the sale of extra vegetables may provide an income for program participants.

Objectives: The aim of this paper was to conduct a feasibility assessment and preliminary impact assessment of a nutrition-sensitive urban agriculture intervention that used sack gardens for women in Kibera.

Methods: Women, from a women's empowerment program, in Kibera ($n = 36$; $n = 21$ full program participants, $n = 11$ withdrawn, $n = 4$ new members) were engaged in a sack garden intervention in June 2018. A mixed-method approach was used to assess the feasibility and preliminary impact of the program. Qualitative semi-structured interviews ($n = 25$; $n = 18$ full program participants, $n = 5$ withdrawn, $n = 2$ new members), administered at the end of the pilot phase (March 2019), identified barriers and facilitators (e.g., preferences, inputs, group dynamics) to the production, consumption, and sale of self-produced vegetables. Quantitative surveys ($n = 21$ full program participants), administered in June 2018 and March 2019, were conducted to evaluate preliminary intervention impact on food security and diet quality through analysis of the Household Hunger Scale (HHS) and Minimum Dietary Diversity for Women (MDD-W).

Results: Key barriers included insufficient inputs and group work difficulties, particularly around communication. Facilitators included positive intervention feedback, social bonds and teamwork, participants' self-sufficiency, and preference for sack garden vegetables over market vegetables. Post-intervention, participants reported reduced household food insecurity. Recommendations for program scale-up include investment in additional inputs, a water-collection/irrigation system, additional training, and placing sack gardens closer to women's homes to reduce time constraints.

Conclusions: This study suggests that sack gardens may provide partial solutions to improve diet quality; however, further research is needed to assess any impact on household income. *Curr Dev Nutr* 2022;6:nzac036.

Keywords: African indigenous vegetables, food environments, food policy, sustainable diets, traditional vegetables, urban agriculture

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Abbreviations used: AMPATH, Academic Model for Providing Access to Healthcare; FANTA, Food and Nutrition Technical Assistance; HHS, Household Hunger Scale; LMIC, low- and middle-income country; MDD-W, Minimum Dietary Diversity for Women.

Introduction

Approximately 25% of the world's population is classified as food insecure (1). The coronavirus disease 2019 (COVID-19) pandemic has exacerbated the strain on global food systems, contributing to an increase in the prevalence of undernutrition (2). Sub-Saharan Africa is one of the regions most affected by undernutrition in the world (3) and poverty is an underlying driver of food insecurity and undernutrition in this region. In Kenya, more than one-third of the population continues to live below the international poverty line, with 35.6% of individuals living on US$1.90 per day or lower (4). This is more pronounced in urban communities, and particularly within informal settlements, which are characterized by inadequate access to safe water, little or no sanitation, poor structural quality of housing, overcrowding, and insecure land tenure (5). Therefore, it is of utmost public health priority to develop sustainable solutions to address food insecurity.

Kibera is one of the largest informal settlements in Africa and is located on the outskirts of Nairobi, Kenya (6). Over 85% of the population of Kibera is food insecure (7) and the prevalence of nutrition-related chronic diseases among women remains high, such that 50% are hypertensive and 43% are classified as overweight or obese (8). At the same time, 47% of children younger than 5 y are stunted, a marker for chronic undernutrition (9). Nutrition-sensitive agriculture interventions, particularly in urban environments such as Kibera, have the potential to improve food security and diet quality by increasing availability, accessibility, and acceptability of nutrient-dense foods (3, 10, 11).

A high-quality diet is one that includes sufficient energy, is balanced in macronutrient content, and adequate in micronutrient intake. Such diets are often compromised in low- and middle-income countries (LMICs) due to high levels of micronutrient deficiencies such as vitamin A, iron, and zinc (12). Consuming a low-quality diet may be particularly detrimental to women who are pregnant or of childbearing age, as micronutrient deficiencies during pregnancy or prior to pregnancy present an increased risk of morbidity and mortality to the infant, which include conditions such as anemia, stunting, and reduced learning and work capacity (13). A low-diversity diet is often associated with a low-quality diet, and typically due to a reduced intake of nutrition-dense vegetables, among other food groups (12). Increasing vegetable intake, such as dark-leafy greens, would serve to improve dietary diversity and micronutrient intake, thereby reducing the likelihood of micronutrient deficiencies (13).

Nutrition-sensitive urban agriculture can contribute to higher food security and food sovereignty levels through the production of nutrient-dense vegetables and can be leveraged to implement new education within resource-poor communities increasing social capital (10, 14). Adequate production of nutritionally dense vegetables may help to address household food and nutrition insecurity through 2 causal pathways: *1*) improved access to nutrient-rich foods and *2*) increased household income either through generating income from the sale of produce or saving income from food expenditures (10). Furthermore, urban agricultural training, particularly when delivered in a group setting, can provide educational opportunities that foster social inclusion, community cohesion, and increase resilience, increasing social capital (14, 15). However, there are gaps in the current evidence base, including a lack of sufficient feasibility assessments of urban agriculture programmatic impact (10); therefore, more research, including feasibility assessments, is needed.

Urban agriculture, an umbrella term for different types of agricultural activities that are conducted in urban settings, includes plant-based farming methods such as roof top gardening, community gardening, potted or container gardening, and sack gardening. It is estimated that 266 million households in LMICs participate in urban agriculture, with approximately 29 million households in Africa (16). In many urban areas across Africa, urban agriculture plays a significant role in providing food to families, contributing to their food security (16). Additionally, it has been demonstrated that urban agriculture can help advance women both economically and socially, providing them with an opportunity to self-sufficiently increase food production for their household as well as an opportunity for employment and improved social cohesion (17). Urban agriculture may be a particularly beneficial approach to improve the accessibility of nutrient-dense foods for vulnerable communities as the majority of the world's population now resides in urban settings.

Sack gardening is an urban agriculture method wherein leafy vegetables are planted in sacks filled with soil, resulting in a garden that grows vertically rather than horizontally in the ground, thereby permitting a far higher number of plants compared with a conventional pot or container. Sack gardening is an urban agriculture method that is well suited to densely populated areas with limited space, such as Kibera (18). The use of sack gardens affords residents of informal settlements who may otherwise not have access to nutrient-dense leafy vegetables the opportunity to produce them within the confined space of a sack. Successful production of leafy vegetables in sack gardens may contribute toward decreasing food insecurity, and increasing dietary diversity, as well as providing economic advantages through saving gardeners the cost of purchasing vegetables from other sources and potentially enabling them to sell vegetables that are not consumed in the household (19).

Sack gardens have a long history of use in several informal settings including Kibera, with increased use in 2008 when a French non-governmental organization called Solidarites provided free seedlings and technical advice to farmers. The program required the farmers to provide all other necessary inputs. A study by Gallaher et al. (17) found that individuals who participated in sack gardening in Kibera had improved food security and dietary diversity compared with non-farmers as well as improved social cohesion, which had a protective effect during times of food stress. While the Solidarites program has demonstrated success, the resource limitations in the informal settlement could present a barrier to participation. The study presented in this paper expanded the programmatic framework provided by Solidarites by supplying the program participants with all required inputs (e.g., sacks, soil, fertilizer, plants), including water when available. Furthermore, the program provided a safe space for the sack gardens and capitalized and expanded on social capital benefits by intentionally having the women work in teams as they trained and grew accustomed to the program (with the intention of obtaining individual sacks for each woman during program scale-up) as well as issuing certificates for program completion.

The objective of this study was to conduct a feasibility and preliminary impact assessment of the preliminary phase, also referred to as the pilot program, of a nutrition-sensitive urban agriculture intervention using sack gardens that engaged members of a women's empowerment program in Kibera. The feasibility assessment examined group dynamics, maintenance of the sack gardens, and program desirability and incentives. Furthermore, this study evaluated the program's preliminary impact on the women's food security and dietary diversity. The food security and dietary diversity results were used to assess if the outcomes of the programmatic framework were aligned with findings by Gallaher et al. (17, 18), demonstrating program feasibility. The feasibility and impact assessment can contribute to lessons learned for program

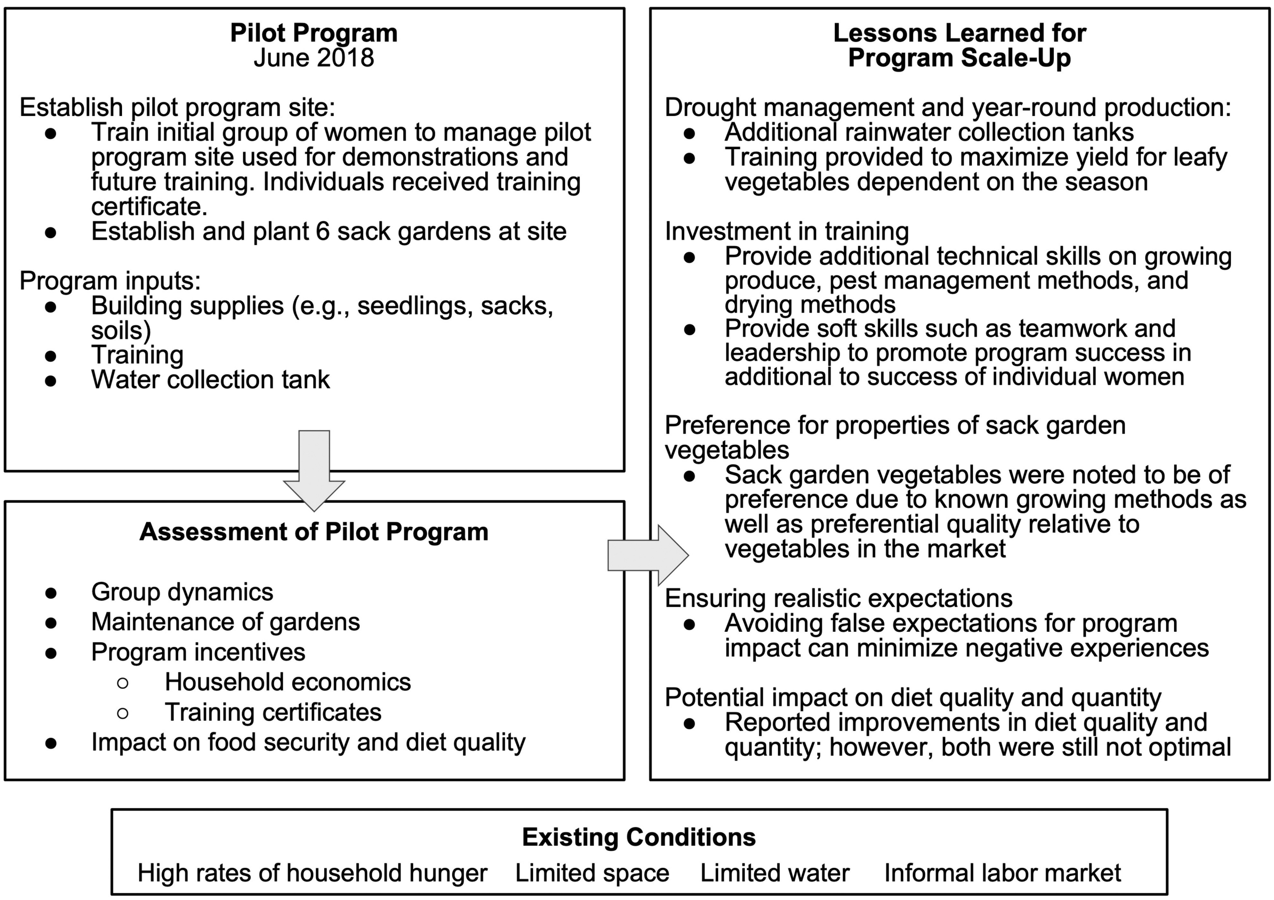

FIGURE 1 Nutrition-sensitive sack garden intervention feasibility and preliminary impact assessment framework.

scale-up as well as additional urban agricultural programs in informal settlements globally.

Methods

This study focused on the feasibility and preliminary impact of a nutrition-sensitive urban agricultural program that used sack gardens in Kibera, Nairobi. Ethical approval in the United States was provided by the Institutional Review Board at Rutgers University, the State University of New Jersey. Ethical approval in Kenya was provided by the Institutional Research and Ethics Committee at the Academic Model for Providing Access to Healthcare (AMPATH) in Kenya. All study participants provided informed oral consent to participate in the study and for use of the data in publications. The use of oral consent was approved by the ethical review boards due to minimal associated risk and low literacy rates among the study population. Subjects were not compensated for participation in the study and were informed that there were no direct benefits from participating in the study; however, the ability to improve the program through the collection of the study data could provide benefits to future participants. The data were anonymized at the time of data collection using a code and authors AZ, EVM, and SD were responsible for the security of the data. Upon completion of the data analysis, the research team shared the data with the partnering organization (Mirror of Hope, Nairobi, Kenya) to disseminate with program participants and inform program growth.

Study setting

Kibera is the largest informal settlement in Kenya with an estimated population of 700,000 people of diverse ethnic backgrounds (6). The majority of people living in Kibera are engaged in the informal economy, with relatively low and unpredictable incomes, and jobs are often exploitative (5). Kenya has 2 growing seasons as determined by rainfall (March to May and October to December), where the dominant growing season east of the Rift Valley (where Nairobi is located) is October–December (20–22).

Program evaluation

The evaluation of the nutrition-sensitive urban agriculture program combined a feasibility and impact assessment with a value chain analysis (**Figure 1**). The semi-structured interviews ascertained questions across the value chain. The responses were initially analyzed by a member of the study team (AZ), who was not involved in the design or administration of the interviews. The quantitative surveys were analyzed for preliminary programmatic impact on food security and dietary diversity.

Nutrition-sensitive urban agricultural program design

The nutrition-sensitive urban agricultural program used sack gardens to maximize vertical space and inputs. The pilot program took place in June 2018, with a small group of women ($n = 32$) recruited from a women's empowerment program run through Mirror of Hope Community Based Organization in Kibera, Kenya. Each woman was randomly assigned to 1 of 6 groups (4 to 6 women per group) by a Mirror of Hope employee. All members of the women's empowerment program were invited to participate in the pilot program; therefore, there were no exclusion criteria.

Figure 2 provides an overview of the construction of the sack gardens (19) and supplemental training. The sack garden training was designed and provided by an agronomist from AMPATH in Eldoret, Kenya, over the course of 2 d. The training focused on the construction of the sack gardens, and how to care for them and harvest them once they were planted. The program provided all required inputs to build the sack gardens (e.g., soil, manure, sacks, center pole, stones, and plantlets). Soil analysis and comparative plant nutrient analysis were conducted to ensure there was no contamination (23, 24).

The sack gardens were placed in a fenced schoolyard adjacent to Kibera for security. The intention of congregating the sacks within a location, termed "program training site," was 2-fold: it allowed for ease of monitoring and evaluation of the feasibility and preliminary impact of the pilot program and also created an area to train future program participants. In total, the program training site consisted of 6 sacks, 1 per group.

The sacks were initially planted with Ethiopian mustard plantlets (*Brassica oleracea*), commonly referred to as *kanzira* in Swahili, due to preference by the program participants and availability. Ethiopian mustard is a type of African Indigenous vegetable, which were emphasized in the training. African Indigenous vegetables either originated in Africa or have a long history of cultivation and domestication to the conditions of Africa and are acceptable through custom, habit, or tradition (25, 26). They are often culturally preferred (27–31) and nutritionally dense (32, 33). Furthermore, they are adapted to the local environmental conditions (31) and some are even considered "survivor plants" due to their tolerance to temperature and precipitation extremes (22). Mirror of Hope staff members managed the program after the initial training and conducted additional training for new program members.

Study sample

Figure 3 provides a program schematic outline of program engagement over the program period. Thirty-two women participated in the initial pilot program. Between June 2018 and March 2019, 11 women withdrew from the program and 4 new members were trained. All women who participated in Mirror of Hope's women's empowerment program were invited to participate in the pilot program, which could have led to self-selection bias that contributed to program retention; however, a high attrition rate was anticipated due to instability within the informal settlement (35, 36). The program administrators reported sickness, returning to the rural villages, and employment as reasons for program withdrawal.

Semi-structured interviews

Semi-structured interviews were conducted in March 2019 with 18 of the 21 women who participated in the full program, in addition to 5 women who had withdrawn, and 2 new members for a total of 25 semi-structured interviews. All semi-structured interviews ($n = 25$) were included in the analysis. The semi-structured interviews focused on the steps of the food supply chain: inputs, production, harvest, processing, storage, sale, and consumption. In addition, the interviews included questions about group dynamics and program satisfaction. A copy of the interview guide can be found in **Supplemental Appendix A**. The questions were designed to examine the processes, actors, incentives, and disincentives that take leafy greens grown in Kibera from microplot to plate. All interviews were audio-recorded, translated into English (for those interviews conducted in Swahili), and transcribed verbatim. The interview transcripts were open-coded and organized based on key themes related to each step of the food supply chain using NVivo (QSR International Pty Ltd. Version 12 Pro). Data were analyzed to evaluate the group dynamics, garden maintenance, program incentives, and programmatic impact on diet quality allowing for the identification of lessons learned that can be applied to program scale-up.

Quantitative surveys

Quantitative surveys were conducted in June 2018 for all initial program participants ($n = 32$; $n = 21$ full program members, and $n = 11$ withdrew) and in March 2019 for the women who participated in the full 8-mo program ($n = 21$) and the new members ($n = 4$). The survey contained 3 sections: household demographics, a modified Food and Nutrition Technical Assistance (FANTA) III Household Hunger Scale (HHS) (37), and FANTA III Minimum Dietary Diversity for Women (MDD-W) (38). A copy of the survey can be found in **Supplemental Appendix B**. This study utilized the HHS FANTA III but omitted the frequency questions due to time constraints. HHS was calculated for each respondent ($\leq$3, 4–6, and 7–9 represent mild, moderate, and severe household food insecurity, respectively). An open 24-h dietary recall with foods aggregated into the following 10 categories was used to calculate MDD-W: grains, white roots, plantains; pulses; nuts or seeds; dairy; meat, fish, or poultry; eggs; dark-leafy greens; vitamin A–rich fruits or vegetables; other vegetables; and other fruits. Mixed dishes were coded for each major food group represented. A score of 5 or more food groups is a proxy for nutrient adequacy among women (38). In March 2019, an additional section was added to the quantitative survey to assess sack garden participation. Women were asked about the number of sacks they tended to as well as the activities, and time commitments, they would perform relative to garden maintenance. The survey was administered in Kiswahili by trained enumerators.

Descriptive statistics (means and frequencies) were used to summarize household demographics, MDD-W, HHS, and sack garden program participation. Demographic data were analyzed in June 2018 for women who participated in the full program and those who later withdrew and in March 2019 for new members. A Kruskal-Wallis H test was used to examine the differences in means between the sample populations (e.g., age of respondent, household size, number of meals consumed). A Fisher's Exact test was used to evaluate population differences in the remaining categorical data (e.g., education level, marital status). Preliminary program impact, which was assessed using HHS and MDD-W, was analyzed for women who participated in the full 8-mo program. A paired t test was used to examine differences in the means between time points for HHS and MDD-W. A McNemar's Test was used to calculate statistical differences between categorical data (e.g., food

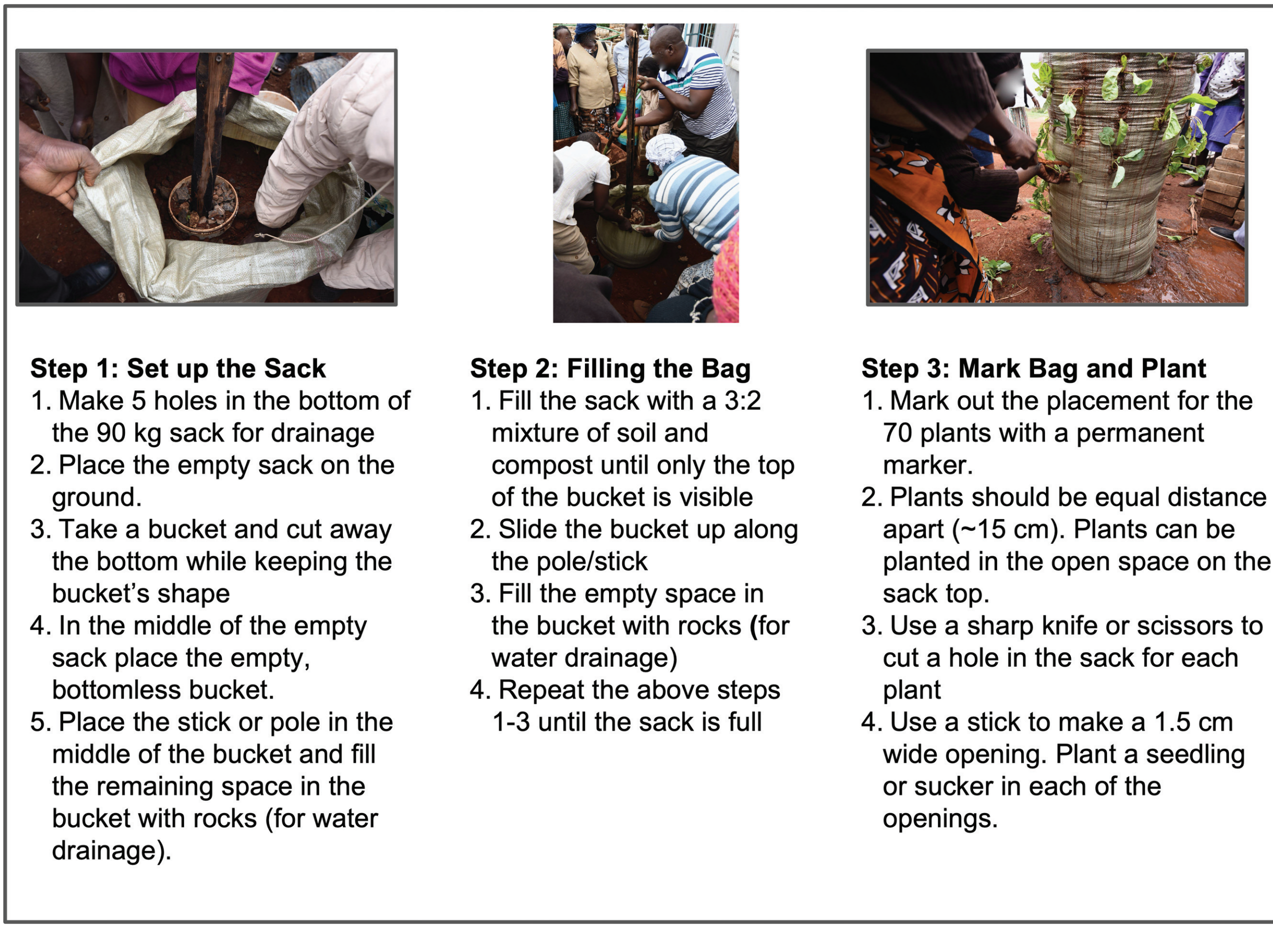

FIGURE 2 Overview of sack garden construction

groups consumed and household hunger categories). Pairwise deletion was used to handle cases of missing data. Quantitative analyses were conducted using SPSS (IBM SPSS Statistics version 26; IBM Corporation) and a P value < 0.05 was used to denote statistical significance.

Results

The implementation of the nutrition-sensitive urban agricultural program revealed challenges and facilitators to the sack garden pilot program. The following section is organized based on the areas of evaluation: demographics, group dynamics, program participants' perception of programmatic success, garden maintenance, program incentives, and preliminary impact on food security and dietary diversity. This evaluation, and subsequent lessons learned, can be applied to program scale-up and additional urban agricultural programs.

Demographics

A summary of the demographics of our study participants is provided in Table 1. On average, the women were 41 y old, completed primary school (38.9%), were married (52.8%), were the head of the household (72.2%), and were self-employed (72.2%). Women reported a variety of informal jobs, the most common being selling fruit and/or vegetables, washing clothes, household help, and selling other foods. Women who participated in the full 8-mo program reported consuming significantly fewer meals in the past 24 h compared with those who withdrew and the new members ($P = 0.008$). Some program participants (22.2%) reported maintaining a garden other than a sack garden.

Group dynamics

The women reported tending to the garden either alone, in pairs, or in subgroups and noted that they followed a schedule so that the garden was tended to regularly:

> "In my group, we were 6 in number, so we used to visit the farm 2 at a time." (Participant 20, age 32)

This division of labor was decided between the group members to maximize programmatic potential. Participant 7 (age 42) summarized the decision making by stating, "We saw that if we pluck all of us it will interfere with the cropping, second we would not get enough food for all of us and third to avoid quarreling which is not good, so we sat down and planned it that way."

With respect to dividing yield, when the vegetables were plentiful, the groups were able to share: "When they are much, everyone will have

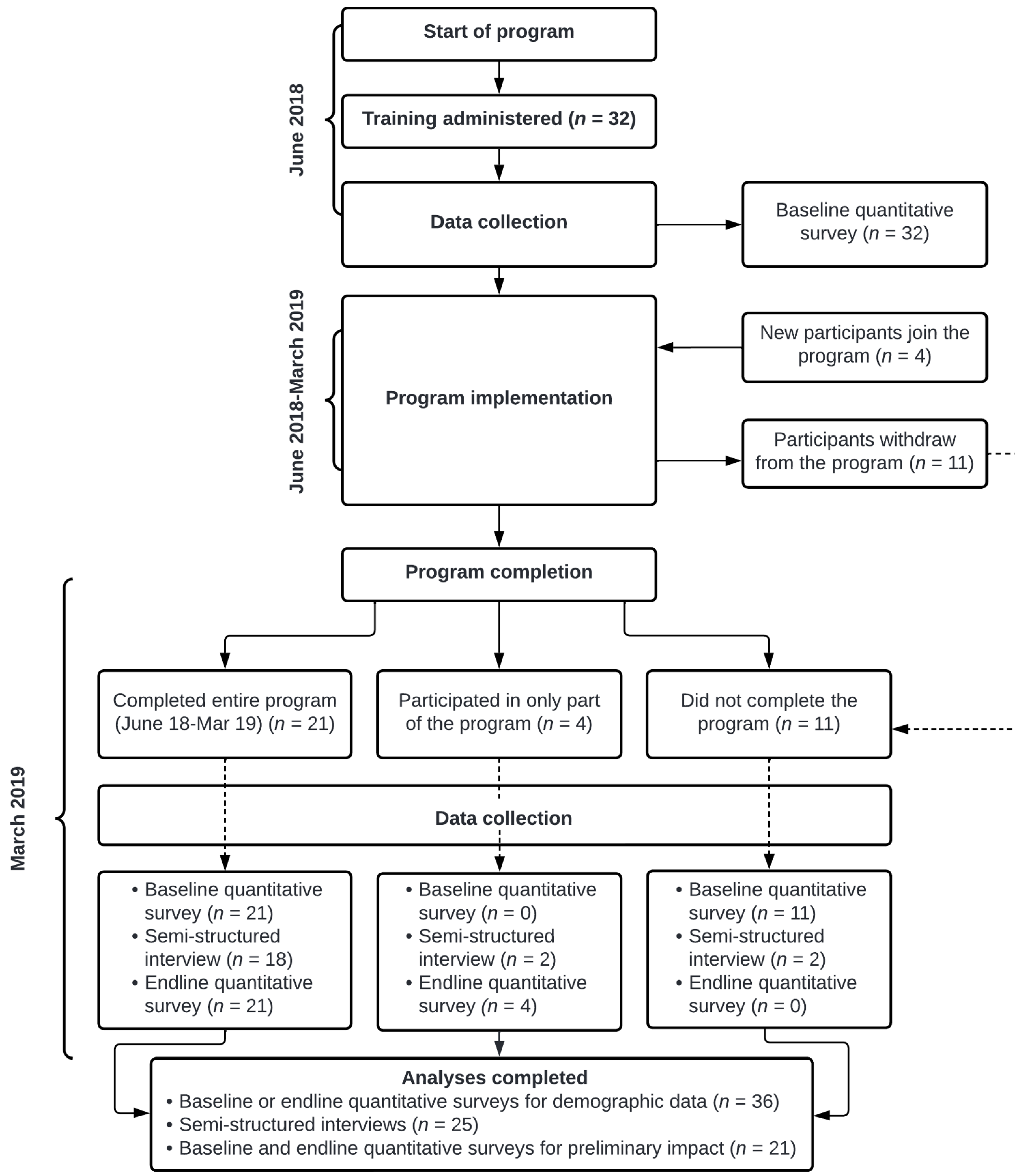

FIGURE 3 Nutrition-sensitive urban agricultural sack garden participant flow diagram.

a small share . . . you divide, when you harvest today, another person tomorrow" (Participant 5, age not available).

Some women indicated that they appreciated the support that their group provided. In some instances, the groups were reported to be a source of joy for the women and a means to contribute to the broader community. Participant 3 (age 45) summarized this by stating:

> "…it strengthens you even if you feel weak you have to be with the rest. When you are doing that work when we laugh you have no stress and that's our joy . . . . We owned up the responsibilities because it is not benefiting you alone, it is benefiting you, benefiting the other, the family, and me. Even the neighbor is also benefiting because he can't sleep hungry, and you have vegetables there."

While group dynamics and garden maintenance were reported to go relatively well, particularly when water was readily available, the shared responsibilities of caring for the sack gardens created unique challenges, such as group members not doing their part after the division of responsibility was agreed upon, group members arriving late, and miscommunications among group members. For example, 1 woman reported, "they can come to an agreement that today we are going to tend to the sack gardens and then the others come, and one fails to turn up" (Participant 16, age 34). Some of the repercussions of this were summarized by Participant 7 (age 42): "We created a schedule where one member goes to the garden to water, but some wouldn't. This led to the vegetable not growing and getting bad."

TABLE 1 Household demographic characteristics of full program participants, withdrawn members, and new program members

Demographic characteristics	All members (*n* = 36)	Full program participants (*n* = 21)	Withdrawn members (*n* = 11)	New members (*n* = 4)[1]	*P*[2]
Data collection date	—	June 2018	June 2018	March 2019	
Age, mean ± SD, y	41.5 ± 8.2	42.2 ± 7.2	42.6 ± 9.8	35.0 ± 7.7	0.241
Household size, mean ± SD, *n*	6.1 ± 2.6	6.1 ± 2.7	5.6 ± 2.6	7.0 ± 1.4	0.568
Live with children <5 y, %	47.2	47.6	36.4	75.0	0.495
Respondents are head of household, %	72.2	81.0	72.7	25.0	0.103
Employed, %	25.0	14.3	45.5	25.0	0.345
Self-employed, %	72.2	81.0	45.5	100.0	0.078
Maintain a garden other than sack garden, %	22.2	23.8	27.3	0.0	0.46
Number of meals consumed in past 24 h, mean ± SD	2.1 ± 0.7	1.8 ± 0.6	2.5 ± 0.5	2.5 ± 0.6	0.008[3]
Educational level, %					0.091
None	2.8	0.0	9.1	0.0	
Some primary school	30.6	47.6	9.1	50.0	
Completed primary school	38.9	28.6	54.5	0.0	
Some secondary school	5.6	9.5	0.0	0.0	
Completed secondary school	22.2	14.3	27.3	50.0	
Marital status, %					0.541
Married	52.8	42.9	54.5	100.0	
Regular partner living together	16.7	14.3	27.3	0.0	
Regular partner living apart	2.8	0.0	9.1	0.0	
No relationship	8.3	14.3	0.0	0.0	
Widow	16.7	23.8	9.1	0.0	

[1]Data were collected in 2019 because participants were not involved in the program at the time of baseline data collection.
[2]Continuous variables (e.g., age of the respondent, household size) between sample populations were compared using Kruskal Wallis H test and categorical variables were compared using Fishers Exact test.
[3]$P < 0.05$ (Kruskal Wallis H Test).

The harvested dark-leafy greens were shared among group members, who were all food insecure, putting an increased strain on the group dynamics. Since women worked in groups, this decreased the quantity of leafy greens available for each individual's household utilization. Participant 10 (age 43) summarized this by stating, "The sacks were few and we were many, so I could not be able to get the vegetables each and every time whenever [I] am in need because my partner also [has] taken the vegetables."

In addition to the intergroup dynamic challenges, there were also challenges that arose between groups. High demand for the leafy greens resulted in sack garden theft between groups. A small number of women indicated that people who were not a part of their sack garden group harvested vegetables in their sacks: "… when ours do well they just pick so when it's your turn to pick, you find that it was picked yesterday and you go without…." (Participant 8, age 45).

Participants' perception of programmatic success

Overall, program participants expressed that the sack gardens were successful, which was attributed to good programmatic structure (e.g., supply of required inputs and support) as well as good group dynamics: "cooperation and working together has really contributed to our success" (Participant 6, age 50). In addition, frequent irrigation during the rainy season and use of homemade biopesticides contributed to the successful production of dark-leafy greens contributing to household food intake, and at times, sales of the excess leafy greens. Despite this, a few women noted the program was not a success.

Program participants offered numerous suggestions on how to improve the program as it is scaled to accommodate 1 sack per participant. Relative to sack garden construction and maintenance, it was suggested that the program establish better drought management via additional water collection facilities, provide a kiosk to sell vegetables, and grow additional types and varieties of vegetables (e.g., onions, tomatoes, peppers). Relative to programmatic structure, it was suggested that additional sacks (at least 1 per woman) be provided closer to the participants' homes (when available). In addition, it was suggested that the program offer additional training, better group management, and small loans to help women establish their sack gardens and associated businesses (e.g., build a kiosk). In addition to group dynamics and participants' perception of programmatic success, opportunities and challenges were presented in specific themes within the maintenance of the sack gardens.

Garden maintenance

Irrigation.

The lack of sufficient water over the dry season, due to drought, was the main challenge related to garden maintenance. While the program training site contained a water-collection tank, this was insufficient to withstand the water shortages during the long drought. Subsequently, the cost of water was high, which compounded the difficulty of accessing sufficient water. More than one-third of all the challenges reported (17 out of 46 reported challenges across all participants) were related to drought/lack of water availability for maintaining the sack gardens. When water from the collection tank was unavailable, women purchased water, which was a challenge as the cost of water was high as summarized: "It affected [me] because, in 3 weeks I was going there, there was no water. I didn't have money in my own pockets to go and water. That was my big challenge" (Participant 1, age 41). Women who could afford to purchase and transport water did so, but some of these women ceased gardening once they could no longer afford to buy water.

Garden inputs.

In addition to water, the garden required several inputs throughout the growing season, such as pesticide, seeds and seedlings, and manure. During the initial training period, participants were taught how to create biopesticide made with chili peppers (a local variety called *pilipili*), neem leaves, soap, and aloe vera. In addition, a few women reported using wood ashes to prevent pest damage. The majority of women who used this information to make and use the pesticide reported that it reduced or eliminated their pest problem entirely: "…we went and prepared the pesticide just as the trainer had taught us, we didn't buy the pesticide, so we prepared it…we sprayed on all the sacks and the pests died" (Participant 8, age 45). While some of the materials for the pesticide were readily available in their homes (e.g., peppers, aloe vera, soap), some women noted issues finding ingredients such as neem oil: "…but the problem that was there mostly was for making the pesticides, the herbs from the trees was hard to be found…" (Participant 24, age 40). Providing the women with pertinent knowledge increased self-sufficiency and helped facilitate production and maintenance of the gardens, representing an efficient and low-cost solution to a common problem.

During the growing season, the women were able to replant their sack gardens with a variety of dark-leafy vegetables. Some women noted starting new plants from suckers, while others mentioned buying seedlings from local vendors or planting seeds. The women noted that it takes about a month for plants and suckers to establish themselves before harvest can begin. African Indigenous vegetables such as Ethiopian mustard (kale), Swiss chard, amaranth, and African nightshade were the most reported vegetables grown in the sack gardens (**Supplemental Table 1**) due to their desirability and accessibility, as stated by Participant 4 (age 28): "Because kale is one of the most used vegetables, we decide to grow it. The most loved vegetables, the *terrere* and the *managus*." Moreover, it was reported that these vegetables were chosen for their nutritional value: "I chose it because I like it, it is very good to the body" (Participant 23, age 32). In addition to African Indigenous vegetables, some women reported growing onions. To help the vegetables grow, some women bought "manure that we use from goats, chicken…" to amend the gardens (Participant 23, age 32).

Time constraints.

The reported frequency of tending to the gardens varied, with the most common being twice a week (33.3%). Additional frequencies included daily or once, 3 times, or 4 times per week. The time spent tending the garden during each visit ranged from a half-hour to 4 h, with the most frequently reported amount being 1 h per visit. In addition, most women reported that they had to walk at least 30 min each way to the sack gardens.

In the surveys, women noted the following as typical activities completed while tending to the sack gardens: watering (33.3%), weeding (23.8%), harvesting (4.8%), pest control (4.8%), and other (4.8%). In March 2019, a majority of the women (76.2%) noted a pause in their work with the sack gardens (however, not complete program withdrawal), with drought (47.6%), illness (14.3%), or family issues (9.5%) noted as the reason for the break. Maintenance of the sack gardens was a labor- and time-intensive endeavor that put the participants, who had other responsibilities such as child or household care, or working outside the home to generate income, in the position of deciding whether they could dedicate time to participating in the program. Several women indicated that they could not participate in the program (or that they had begun the project and then had withdrawn) because they had other commitments that took priority. One woman stated:

> "When [I] am needed to go to the group and at the same time [I] am needed to get food for the household, that is also a challenge which puts me in a dilemma where to go and I just decide to go and get food" (Participant 13, age 54).

Another woman reported, "The challenge I had was about children. About money, [in] June, I had issues to do with school fees, rent so all those issues were disturbing me" (Participant 14, age not available).

Program incentives

Household economics.

When the harvested leafy vegetables were shared among program participants, yields were often insufficient for both household consumption and sales. Nearly all of the women prioritized feeding their families rather than selling the leafy vegetables as summarized: "I have a family, so I thought there is no need of selling them then buy again, so it is better [for] my family to eat them" (Participant 3, age 45). Consuming self-grown vegetables reduced the money the women would have had to use to purchase vegetables at the market. Participant 23 (age 32) summarized this by saying: "It helps me because I save money, I don't buy vegetables outside I just pick it here, the money that I could use to buy I use it to buy something different, like flour. . . ." If the women had enough leafy vegetables to sell after household consumption, they reported selling to their neighbors, with 1 woman reporting that she sold them to "someone passing by," indicating that there was interest in purchasing the vegetables in the local community. Many women provided feedback that they would sell leafy vegetables (or sell more) if they had the chance: "If given an opportunity, I would like to sell" (Participant 19, age 32). When asked how the program could be improved, more than half of the women stated that a greater number of sack gardens would produce a greater supply of leafy vegetables, which would provide increased opportunity to sell them: "I would suggest if it is possible we get a garden where we can plant like 10 sacks or 20 …then the vegetables would thrive and grow big, for that even when you harvest, you will be able to sell much compared to these from one sack which you can only eat and don't sell" (Participant 13, age 54).

Self-sufficiency.

Despite the low quantity of leafy vegetables per participant, there were instances of women demonstrating motivation and self-sufficiency to increase production, whether by constructing additional sack gardens, utilizing the training they received to replant the sack gardens, utilizing low-technology solutions to store leafy vegetables to prevent spoilage, and/or mitigating pests to increase yield. To expand their opportunities for both consumption and sales, some program participants took initiative to construct additional sack gardens. In March 2019, 57.1% of the program participants reported managing more than 1 sack garden (mean ± SD: 2.1 ± 1.3 sack gardens). A few women even acquired land or permission to utilize land to create additional sack gardens outside of their group. These additional sacks increased the number of leafy vegetables for household consumption, storage, and sale. Furthermore, some (24.0%) women responded to harvest loss by replanting the garden, demonstrating that the women were motivated and able to go to great lengths to produce leafy vegetables:

> "The sack garden when we started in June…it did well at first and from June to like October…it started getting some drought so we tried as much as we could, we could not even get water to pour in our sack gardens, so it affected our sack gardens and the vegetables there dried up. So…this year [in] February, we saw it's good enough to at least restart again to plant some sack gardens again" (Participant 10, age 43).

During initial training, program participants were taught how to store vegetables without utilizing water or other potentially unavailable resources. One woman was able to explain what she was taught to do: "We were taught you can preserve them without fridge. You harvest then you wash them, cut then you make sure it does not have water and you put in a polythene paper. It takes a very long time before it spoils" (Participant 20, age 32). Thus, there is a low-cost, water-free storage method available to and readily understood by the women.

Preference for sack garden leafy vegetables.

Participants preferred leafy vegetables produced in the sack gardens compared with those purchased at the market. The leafy vegetables grown in the sack gardens were thought to be "sweeter," "fresher," "softer," and "cleaner." There was also an added enjoyment to consuming vegetables that were self-grown and in knowing where the food came from, which contributed to improved well-being. Participant 7 (age 42) shared the following:

> "They are very fresh, soft and sweet because I pluck them myself. Those ones in the market are not fresh because you may find that they had been plucked like 3 days ago. Especially when you go to the market very late in the evening when it's dark you can buy something that when get back home you can even cry."

Furthermore, when asked if their families enjoyed the vegetables from the sack gardens, program participants expressed that confidence in the quality of the growing media and garden inputs was a further incentive for household consumption. Participant 22 (age not available) expressed this by saying: "You know they see it as fresh vegetables that you harvest individually, not like that you buy from the market that you even don't know where it came from, so they are happy that it is you who have planted, and you harvest them when they see and you prepare as they see."

Training and certificates.

The training certificate that accompanied this program was an added programmatic incentive. Participant 22 (age not available) expressed this by stating the following:

> "I was very excited for that training, mostly because there is that skills that I came out with and I learned something. I wanted to know so that when [I] am in a place, even if it is a small compound, I can plant vegetables and not lack vegetables, this small compound I will put vegetables in the sacks, and I was asking myself how do people grow these vegetables, so I had an urge to know how it is grown."

A majority of program participants (90.5%) expressed an interest in receiving a program completion certificate. Acquiring a job, validation of knowledge, social status, and ability to teach others were reported as reasons for wanting the certificate. Several women passed on the knowledge they gained to others:

> "I got the knowledge and skill[s] and I can even train others…and they can pay me something little for me to train them, that will be helping them. I can help someone, and she can train someone else" (Participant 21, age 47).

There was expressed desire for further training in topics ranging from production and inputs (e.g., drought management, pest control, growing a greater variety of leafy vegetables), to post-harvest handling (e.g., drying and storage) to preparation techniques (e.g., cooking recipes). In addition, some women requested a periodic refresher course as well as training on how to train others.

Preliminary impact on food security and dietary diversity

The MDD-W, HHS, and consumption of food groups between pre- and postintervention (June 2018 and March 2019, respectively) are shown in **Figure 4**. There was an observed increase in MDD-W score in March 2019 as compared with June 2018; however, this increase was not significant (mean ± SD: 2.9 ± 1.1 vs. 3.6 ± 1.4; $P = 0.059$). Furthermore, over the project period, there were reported differences in the food groups that program participants consumed. Respondents noted a significant increase in the consumption of other vegetables ($P = 0.006$). In addition, an increase in consumption of grains, white roots, and plantains; pulses; meat, fish, and poultry; and eggs were observed; however, the increase was not significant. A decrease in the consumption of dark-leafy vegetables and vitamin A–rich fruit and vegetables was observed but the decline was not significant. It is of note that the postintervention survey was conducted after the drought, which could have contributed to the difference in the reported consumption relative to the positive program feedback. In addition, there was a significant reduction in household food insecurity (mean ± SD: 8.0 ± 1.1 vs. 7.2 ± 1.4; $P = 0.015$); however, when the HHS data were analyzed categorically, there was no significant change, with a majority of respondents reporting being severely food insecure both pre- and postintervention (86% vs 62%; $P = 0.125$).

Discussion

Overall, this study found that the nutrition-sensitive urban agricultural program was positively received by program participants and had a positive impact on household hunger for program participants through 2 causal pathways: *1*) reported increased access to nutrient-dense leafy vegetables during the rainy season and *2*) reported minimized grocery expenditures, freeing household expenses for other food purchases. In addition, some women reported the ability to sell excess vegetables, which was a form of income generation.

The feasibility assessment of the pilot program provided lessons learned that can be applied to program scale-up as well as additional nutrition-sensitive urban agricultural programs. As this program transitions from the pilot phase to program scale-up (intended to accommodate an individual sack for each woman), further benefits may be

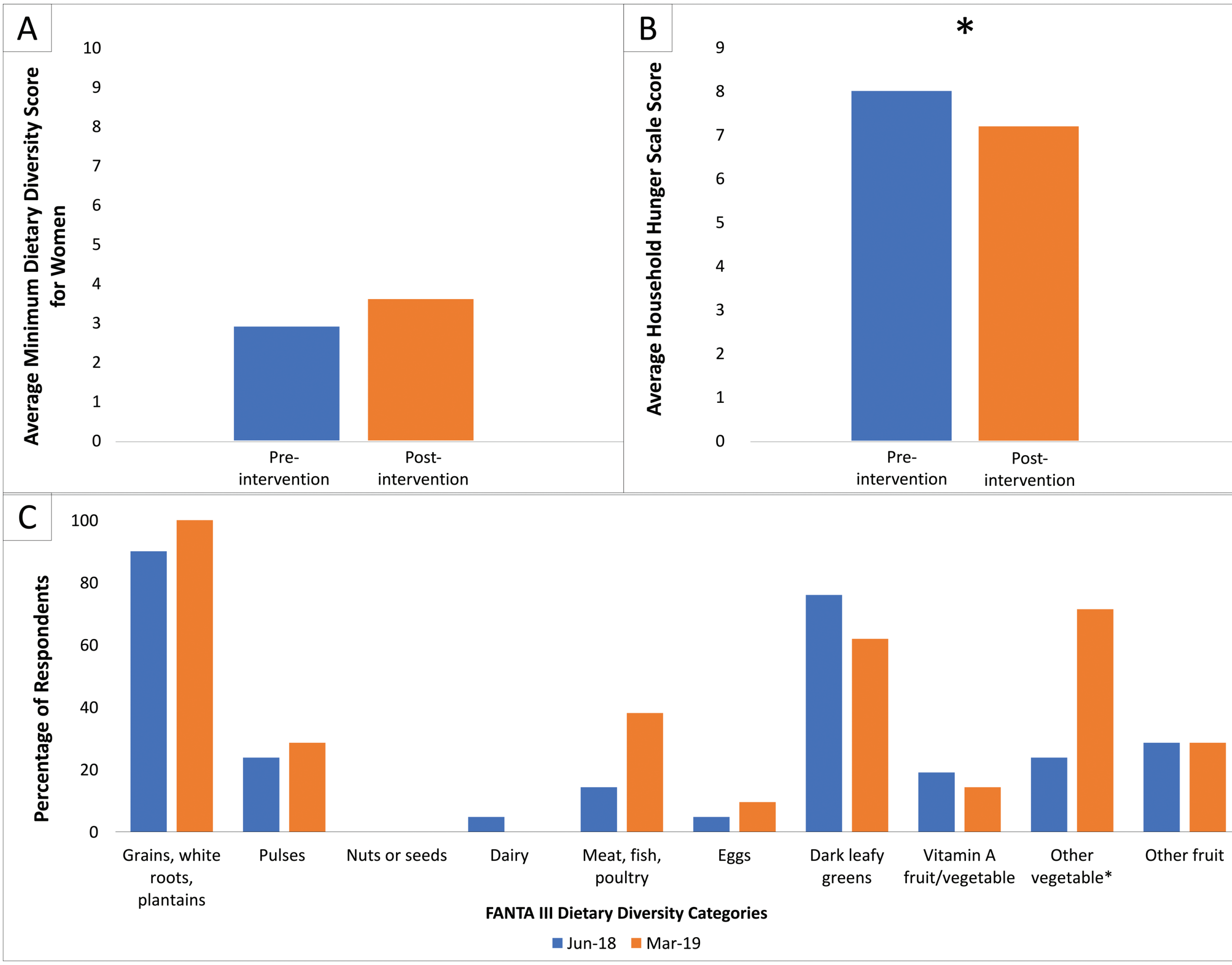

FIGURE 4 (A) Average Minimum Dietary Diversity Score for Women in June 2018 and March 2019. (B) Average Household Hunger Scale score in June 2018 and March 2019. (C) Reported consumption of dietary diversity categories in June 2018 and March 2019. *Statistically significant at $P < 0.05$ (paired t test panel B; McNemar's Test panel C).

incurred as a result of increased yield and subsequent household vegetable consumption and sale.

Lessons learned

Drought management and year-round production.

Drought and subsequent insufficient water supply were the most reported challenges in our study. One potential solution the program administrators could apply is the installation of additional water-collection and irrigation systems that utilize water collected during the rainy season for the dry season (18, 27, 29). For example, a rainwater collection system could be installed on the roof of the buildings on the property to increase the amount of water collected during the rainy season. In addition, policy-level change should focus on improving access to fresh water within Kibera. Globally, communities are increasing access to nonpotable clean water, such as treated wastewater or grey water, which can be used for irrigation and increase participation and success of urban agricultural programs (39, 40). Furthermore, sack gardens could be constructed with material that conserves water. For example, sacks composed of burlap use water efficiently, as water can access roots readily and the sack is able to retain moisture (19).

In addition, to promote year-round urban agriculture production, the seasonality of vegetables could be maximized. For example, some leafy African Indigenous vegetables are more tolerant of the rainy seasons (e.g., jute mallow and amaranth) while others are more tolerant of the dry seasons (e.g., slender leaf, cowpea, and Indian spinach) (22). Future training should incorporate the use of alternative sack garden materials and vegetable seasonality to maximize year-round yield.

Investment in training.

Ensuring access to robust initial training and additional training sessions on additional topics not offered in this study could lead to increased sack gardening participation and African Indigenous vegetable production. Evidence has shown that a lack of skills and knowledge to operate sack gardens is a barrier to participation (18). During the study, many women reported an interest in receiving additional training about growing fruit or vegetables other than the types offered, pest management methods, and drying methods. A key indicator that the women were both able and willing to use the knowledge they acquired is evident from the observation that most women in this study used the pest management method they were taught during their initial training. In addition to these technical skills, women expressed interest in receiving training for teaching others the sack garden skills.

Contributions of teamwork.
Women noted that having their group to rely on for assistance with garden maintenance as well as knowledge sharing was an important aspect of the program that would persist even as the program scaled to provide an individual sack garden per woman. While positive attributes of the group dynamics were reported, there were some challenges in communication and leadership, which could be improved through further training. Improving the participants' soft skills, such as leadership, teamwork, and communication, through training could help promote social cohesion, even during program scale-up. This, in turn, could contribute to teamwork for the success of the entire program and wellness for the program participants beyond dietary diversity and quality. It is important to facilitate these dynamics through training as they contribute to community cohesion and overall well-being for program participants (14, 15).

Preference for reported properties of sack garden leafy vegetables.
Leafy greens, particularly African Indigenous vegetables, such as Ethiopian mustard, spider plant, and nightshade, which were grown in the sack gardens, are nutrient-rich, culturally appropriate vegetables that can grow in low-water conditions and limited space such as that found in an urban setting (30). The leafy greens produced in the sack gardens, relative to those found in the market, were considered to be of high quality by the study participants due to their knowledge of the precise production methods used (e.g., no pesticides or added chemicals). While leafy greens can offer diverse macro- and micronutrients, such as vitamins (e.g., folate, vitamins A and E), minerals (e.g., iron), carbohydrates, proteins, fats, and bioactive compounds such as antioxidants (32, 33), the specific nutritional profile may be dependent on environmental factors (41). It is essential that growing conditions are tested to ensure that the soil is adequate for growing vegetables without posing potential contamination (24).

Ensuring realistic expectations.
Some of the participant feedback made it clear that there were unrealistic expectations regarding the program's preliminary impact. For example, it was unrealistic that the yield of 1 sack, shared among a group of women, would be enough for both household consumption and sales. This expectation, in turn, created potentially avoidable competition and tension between group members and even between groups. This expectation, however, should have been anticipated as the program participants are severely food insecure and therefore the promise of any amount of food or a source of income holds a lot of weight. To mitigate this programmatic pressure, the initial program training site could be established with more sack gardens and therefore smaller groups (2 to 4 women); however, limitations on space may necessitate larger groups/fewer gardens. In addition, the women could receive a small remuneration for working on the program training site and providing additional training to new program members as well as financial support to help purchase needed inputs, such as the ingredients for the pesticides to maintain the site. In addition, some of the suggested program improvements fell within and informed the given programmatic structure of scaling the program (e.g., at least 1 sack per program participant, gardens located closer to home, etc.). Furthermore, some of the vegetables that were requested fall outside the scope of a sack garden (e.g., maize). This further demonstrates that the program outputs need to be clearer in order to avoid frustration and disappointment among program participants. Improved communication to clearly outline program expectations and goals along the implementation pathway could help foster program success.

Preliminary impact on food security and dietary diversity.
Over the study period, women reported a decrease in household food insecurity and an increase in dietary diversity. These results are consistent with other research that found increased food security and dietary diversity as a result of sack gardening participation in Kibera (17). Despite these improvements, the postintervention MDD-W average was still well below the minimum threshold of 5, indicating a population whose diet was not meeting adequate nutrient intake. In addition, while pre- and postintervention data indicated a shift in dietary patterns (e.g., increased intake of other vegetables; grains, white roots, and tubers; meat, fish, and poultry), there was a reported decrease in the consumption of dark-leafy vegetables, the target food group for the intervention. This could be the result of the shift in season between the pre- and postintervention survey. The semi-structured interviews captured the women's reflection of how the sack gardens positively contributed to household dietary intake during the rainy season and when water for irrigation was available; however, the quantitative survey captured the reality of how droughts impact diet quality despite the intervention efforts. Programs need to take into consideration this reality when designing urban agricultural interventions and a sufficient rainwater collection system needs to be installed at the onset of the intervention. Furthermore, policy-level change that increases assess to water safe for irrigation should be emphasized.

In addition, postintervention, the average participant was still considered to have "severe household hunger." While there were improvements in food security and dietary diversity, there was still strong evidence of suboptimal consumption. This aligns with other studies conducted in Kibera, which have found that over 80% of the population is food insecure, with 50% being severely food insecure (7). While these improvements in diet quality and food security suggest that there may be benefits to engaging in sack gardening among women in Kibera, it is only 1 pathway towards mitigating food insecurity and sovereignty. Additional programming, such as remuneration for maintaining the program training site and training new members, as well as policy-level change need to be enacted to fully address this issue.

Limitations

This study had several limitations. First, this was a feasibility assessment that recruited women from a women's empowerment program for an urban agricultural program, and some of these women had agricultural experience. Therefore, the results may not be representative of other women living in Kibera, as engagement in both programs may demonstrate an aptitude and greater interest in urban agriculture before enrollment into the program, and therefore results may not be generalizable to a broader audience. Second, the methods did not include a control group and therefore it is not possible to detect if outside influences such as seasonality contribute to reported consumption changes. Third, this study engaged a relatively small sample size, which included high attrition rates, which may have limited the ability to detect differences in outcomes pre- and postintervention as well as inflate the significance of the study findings. Despite these limitations, this feasibility assessment provides important insights into the barriers and facilitators to developing and implementing an urban agricultural program in an informal settlement. Furthermore, it highlights the preliminary positive impact on diet quality and quality for program participants.

Conclusions

This study demonstrated that the use of sack gardens in an urban agricultural program was feasible and had positive contributions to the program participants (e.g., food security and dietary diversity); however, there were barriers to program success that need to be taken into consideration for program scale-up. Future programming needs to take into consideration drought-management strategies. Furthermore, as this program scales, opportunities for further training, and additional inputs (e.g., seeds, pest management materials) should be considered and incorporated into robust training of both technical and soft skills. These opportunities could meet increased household vegetable demand and contribute to household finances, either from selling excess vegetables or savings from grocery expenditure. In addition, it should be recognized that sack gardens pose challenges, including utilization of contaminated soil, security of produce from theft, and limited options relative to the procurement of needed inputs, and approaches should be incorporated to mitigate against such risks. Nutrition-sensitive urban agriculture such as sack gardening represents an intervention that has the potential to impact public health through the pathways of food security, nutrition, and well-being.

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Data Availability

The datasets generated for this study are available on request to the corresponding author.

References

1. United Nations Department for Economic and Social Affairs. Sustainable Development Goals report 2020. Rome (Italy): United Nations; 2020.
2. FAO; International Fund for Agricultural Development; UNICEF; World Food Program; WHO. The state of food security and nutrition in the world 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all [Internet]. FAO, Rome (Italy): 2021. Available from: https://doi.org/10.4060/cb4474en.
3. Timler C, Alvarez S, DeClerck F, Remans R, Raneri J, Estrada Carmona N, et al. Exploring solution spaces for nutrition-sensitive agriculture in Kenya and Vietnam [Internet]. Agric Syst 2020;180:102774. Available from: https://doi.org/10.1016/j.agsy.2019.102774.
4. United Nations World Food Programme. World Food Programme Kenya country brief [Internet]. 2021. [cited 2022 Feb 8]. Available from: https://www.wfp.org/countries/kenya.
5. Metcalfe V, Pavanello S, Mishra P. Sanctuary in the city? Urban displacement and vulnerability in Nairobi. HPG Working Paper [Internet]. 2011. [cited 2021 Jul 21]. Available from: https://cdn.odi.org/media/documents/7289.pdf.
6. World Economic Forum. These are the world's five biggest slums [Internet]. 2020. [cited 2021 Jul 21]. Available from: https://www.weforum.org/agenda/2016/10/these-are-the-worlds-five-biggest-slums/.
7. Kimani-Murage EW, Schofield L, Wekesah F, Mohamed S, Mberu B, Ettarh R, et al. Vulnerability to food insecurity in urban slums: experiences from Nairobi, Kenya. J Urban Health 2014;91(6):1098–113.
8. Ettarh R, Van de Vijver S, Oti S, Kyobutungi C. Overweight, obesity, and perception of body image among slum residents in Nairobi, Kenya, 2008–2009. Prev Chronic Dis 2013;10:E212.
9. Olack B, Burke H, Cosmas L, Bamrah S, Dooling K, Feikin DR, et al. Nutritional status of under-five children living in an informal urban settlement in Nairobi, Kenya. J Health Popul Nutr 2011;29:357–63.
10. Korth M, Stewart R, Langer L, Madinga N, Rebelo Da Silva N, Zaranyika H, et al. What are the impacts of urban agriculture programs on food security in low and middle-income countries: a systematic review. Environ Evid 2014;3(1):21.
11. Hodge J, Herforth A, Gillespie S, Beyero M, Wagah M, Semakula R. Is there an enabling environment for nutrition-sensitive agriculture in East Africa? Stakeholder perspectives from Ethiopia, Kenya, and Uganda. Food Nutr Bull 2015;36(4):503–19.
12. Ruel MT, Deitchler M, Arimond M. Developing simple measures of women's diet quality in developing countries: overview. J Nutr 2010;140(11): 2048S–50S.
13. Tulchinsky TH. Micronutrient deficiency conditions: global health issues. Public Health Rev 2010;32(1):243–55.
14. Ferreira AJD, Guilherme R, Ferreira CSS, Oliveira M FML. Urban agriculture, a tool towards more resilient urban communities? Curr Opin Environ Sci Health 2018;5:93–7.
15. Ferreira AJD, Pardal J, Malta M, Ferreira CSS, Soares DDJ, Vilhena J. Improving urban ecosystems resilience at a city level the Coimbra case study. Energy Procedia 2013;40:6–14.
16. Hamilton AJ, Burry K, Mok HF, Barker SF, Grove JR, Williamson VG. Give peas a chance? Urban agriculture in developing countries. A review. Agron Sustainable Dev 2014;34(1):45–73.
17. Gallaher CM, Kerr JM, Njenga M, Karanja NK, WinklerPrins A. Urban agriculture, social capital, and food security in the Kibera slums of Nairobi, Kenya. Agric Hum Values 2013;30(3):389–404.
18. Gallaher C, WinklerPrins A, Njenga M, Karanja NK. Creating space: sack gardening as a livelihood strategy in the Kibera slums of Nairobi, Kenya. J Agric Food Syst Comm Dev 2015;5(2):1–19.
19. Andres A. Gardening in a sack handbook: a technique of vertical agriculture [Internet]. Technical and Programme Quality Department of Solidarites International. 2016[cited 2021 Jul 21];25. Available from: https://www.solidarites.org/wp-content/uploads/2017/05/Gardening-in-sacks-2016.pdf.
20. Kisaka O, Mucheru-Muna M, Ngetich F, Mugwe J, Mugendi D, Mairura F. Seasonal rainfall variability and drought characterization: case of eastern arid region, Kenya. In: Leal Filho W, Esilaba AO, Rao KPC,

Sridhar G, editors. Adapting African agriculture to climate change: transforming rural livelihoods [Internet]. Cham (Switzerland): Springer International Publishing; 2015. p. 53–71[cited 2021 Jul 21]. Available from: https://doi.org/10.1007/978-3-319-13000-2_5.
21. Recha CW. Local and regional variations in conditions for agriculture and food security in Kenya [Internet]. Agriculture for Food Security 2030. 2018. [cited 2021 Jul 16]. Available from: http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-p-103571.
22. Stöber S, Chepkoech W, Neubert S, Kurgat B, Bett H, Lotze-Campen H. Adaptation pathways for African Indigenous vegetables' value chains. In: Leal Filho W, Belay S, Kalangu J, Menas W, Munishi P, Musiyiwa K, editors. Climate change adaptation in Africa: fostering resilience and capacity to adapt[Internet]. Cham (Switzerland): Springer International Publishing; 2017. p.413–33. [cited 2021 Jul 21]. Available from: https://doi.org/10.1007/978-3-319-49520-0_25.
23. Brindisi L, Merchant EV, Eliver B, Odhiambo J, Night E, Nyawir T, et al. Comparative nutritional analysis between African Indigenous vegetables grown by urban farmers and those available for purchase in Kibera, Nairobi, Kenya: a case study [Internet]. J Med Active Plants 2020. [cited 2021 Jul 21]. Available from: https://scholarworks.umass.edu/jmap/vol9/iss3/8/.
24. Gallaher CM, Mwaniki D, Njenga M, Karanja NK, WinklerPrins A. Real or perceived: the environmental health risks of urban sack gardening in Kibera slums of Nairobi, EcoHealth 2013;10(1):9–20.
25. Ambrose-Oji B. Urban food systems and African Indigenous vegetables: defining the spaces and places for African Indigenous vegetables in urban and peri-urban agriculture. In: Shackleton C, Drescher A, Pasquini M, editors. African Indigenous vegetables in urban agriculture. London: Earthscan, Dunstan House; 2009. p. 1–34.
26. Towns AM, Shackleton C. Traditional, indigenous, or leafy? A definition, typology, and way forward for African vegetables. Econ Bot 2018;72(4): 461–77.
27. Simon JE, Weller S, Hoffman D, Govindasamy R, Morin X, Merchant EV, et al. Improving income and nutrition of smallholder farmers in eastern Africa using a market-first science-driven approach to enhance value chain production of African Indigenous vegetables. J Med Active Plants 2020;9:289–309.
28. Hoffman DJ, Merchant E, Byrnes DR, Simon JE. Preventing micronutrient deficiencies using African Indigenous vegetables in Kenya and Zambia. Sight Life 2018;32:177–81.
29. Simon J, Acquaye D, Govindasamy R, Asante-Dartey J, Juliani R, Diouf B, et al. Building community resiliency through horticultural innovation [Internet]. Scientia Global 2021. [cited 2021 May 2]. Available from: https://www.scientia.global/building-community-resiliency-through-horticultural-innovation/.
30. Weller SC, Van Wyk E, Simon JE. Sustainable production for more resilient food production systems: case study of African Indigenous vegetables in eastern Africa. Acta Hortic 2015;(1102):289–98.
31. Hunter D, Borelli T, Beltrame DMO, Oliveira CNS, Coradin L, Wasike VW, et al. The potential of neglected and underutilized species for improving diets and nutrition. Planta 2019;250(3):709–29.
32. Abukutsa-Onyango M, Kavagi P, Amoke P, Habwe F. Iron and protein content of priority African Indigenous vegetables in the Lake Victoria Basin. J Agric Sci Technol 2010;4(4):67–9.
33. Kamga RT, Kouamé C, Atangana AR, Chagomoka T, Ndango R. Nutritional evaluation of five African Indigenous vegetables. J Hortic Res 2013;21(1): 99–106.
35. Cramer H, Haller H, Dobos G, Lauche R. A systematic review and meta-analysis estimating the expected dropout rates in randomized controlled trials on yoga interventions. Evid Based Complement Alternat Med 2016;2016:1–7.
36. Chang M-W, Brown R, Nitzke S. Participant recruitment and retention in a pilot program to prevent weight gain in low-income overweight and obese mothers. BMC Public Health 2009;9(424):1–11.
37. Ballard T, Coates J, Swindale A, Deitchler M. Household hunger scale: indicator definition and measurement guide. Washington (DC): Food and Nutrition Technical Assistance II Project, FHI 360; 2011.
38. FAO of the United Nations; USAID's Food and Nutrition Technical Assistance III Project (FANTA). Minimum dietary diversity for women a guide to measurement. Rome (Italy): FAO; 2016.
39. Ashraf M, Safdar ME, Shahzad SM, Aziz A, Piracaha A, Suleman M, et al. Challenges and opportunities for using wastewater in agriculture: a review J Appl Biol Biotechnol 2017;2(2):1–20.
40. Cirelli GL, Consoli S, Licciardello F, Aiello R, Giuffrida F, Leonardi C. Treated municipal wastewater reuse in vegetable production. Agric Water Manage 2012;104:163–70.
41. Rouphael Y, Cardarelli M, Bassal A, Leonardi C, Giuffrida F, Colla G. Vegetable quality as affected by genetic, agronomic and environmental factors. J Food Agric Environ 2012;10:680–8.