Mixed-Methods Implementation Study of a Home Garden Intervention in Rural Guatemala Using the RE-AIM Framework

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ABSTRACT

Background Home gardening is a strategy to improve nutrition and food security. More information is needed about optimizing gardens in different contexts.

Objective The aim was to identify implementation barriers and facilitators for a home gardening intervention in rural Guatemala and inform future larger-scale interventions in the region.

Design A mixed-methods implementation study using the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework was conducted from January 2019 to July 2020.

Participants/setting Families (n = 70) in rural Guatemala participated in the intervention. Staff (n = 4), families (n = 6), and community stakeholders (n = 3) participated in interviews or focus groups.

Intervention Participating households received seeds and seedlings for 16 crops, garden construction materials, agronomist-delivered education and assistance, and a standard-of-care nutrition program.

Main outcome measures Implementation data were collected from program records and observations, participant surveys, and interviews and focus groups. Crop count and nutritional functional diversity of home gardens were assessed.

Statistical analyses performed Descriptive statistics were calculated for quantitative outcomes. Qualitative data were double-coded and organized into overarching themes.

Results *Reach*: Ninety percent of eligible households participated. Child nutritional eligibility criteria was a barrier to reach. *Effectiveness:* Participants and stakeholders felt the intervention improved access to diverse foods. Cultivated crops increased an average of five species (95% confidence interval [CI], 4–6) at 6 months, although not all were consumed. *Adoption:* The main community adoption barrier was water sourcing for garden irrigation. *Implementation:* Raised beds were the most common gardening method, with good adoption of agricultural best practices. Gray water filters and flexible implementation were important for participation. *Maintenance:* Crops failure rates were low. Seed availability was a sustainability challenge. Direct costs were 763 USD per household.

Conclusions Interest and engagement with a home garden intervention in Guatemala were high. Gaps between garden production and consumption, access to water, and seed sourcing should be addressed in future work.

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DESPITE PROGRESS MADE IN recent decades, food insecurity and child undernutrition remain pressing global concerns that have been exacerbated by food system disruptions and household income losses related to the Coronavirus 2019 (COVID-19) pandemic.[1] Home gardening, the cultivation of assorted edible crops near the home for supplemental food or income, has long played an important role as a strategy for strengthening food security and improving micronutrient-rich food access in low- and middle-income countries.[2,3] The documented benefits of home garden interventions for children in low- and middle-income countries include improved growth, dietary diversity, increased vitamin A intake, and reductions in anemia.[4-7] However, implementing home garden interventions is logistically complex, requiring cross-sector coordination, community buy-in, and adaptation to the local environmental and cultural context.[8]

Implementation science research on home gardening interventions is beginning to emerge, although most studies have thus far been conducted in Bangladesh, India, and Nepal. Key findings include the ability of home garden interventions to empower women[9-12] and increase the production of micronutrient-rich foods.[13-16] Documented constraints include irrigation challenges,[14,16,17] competing demands on participants' time,[10,11,13] pests and diseases,[13,16,17] and limited space to plant gardens.[18-20] The most commonly identified barrier to long-term sustainability is access to and cost of quality seeds.[13,17,18,21]

Research Snapshot

Research Question: What was the reach, effectiveness, adoption, implementation, and maintenance of a pilot home gardening intervention in rural Guatemala?

Key Findings: This mixed-methods implementation study found that a home garden intervention in rural Guatemala had high participation and low attrition rates and improved access to diverse foods for participating households. There was good adoption of fencing, organic mulching, staggered planting, intercropping, and use of natural pesticides. Crop failure rates were low. Main challenges to sustainability were water access, seed sourcing, and increasing consumption by households of crops they cultivate.

In recent years, home gardening interventions in Guatemala have increased because of a national nutrition strategy focused on promoting multi-component interventions.[22] However, garden implementation evaluations in Guatemala remain limited. Although most rural Guatemalan households work in food production, the prevalence of food insecurity and childhood stunting are some of the highest in the world.[23] Stunting is associated with lifelong consequences for educational attainment, adult health, and economic prosperity, and it can result in poor birth outcomes for women with short stature.[24,25]

In light of these challenges, this mixed-methods study was conducted with the objectives of using the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework[26-28] to evaluate the reach, effectiveness, adoption, implementation, and maintenance of a pilot home gardening intervention in rural Guatemala. The overall goal was to identify barriers and facilitators and inform implementation, sustainability, and scalability of future garden interventions in Guatemala.

METHODS

Study Design

This mixed-methods study with a convergent parallel design[29] was conducted from January 17, 2019 to July 31, 2020, using the RE-AIM framework.[26-28] The study protocol was approved by the Maya Health Alliance Institutional Review Board (Protocol #WK 2018-002) and the University of New Mexico Health Sciences Center Human Research Protections Office (Protocol #18-619). Participants provided verbal informed consent. The trial was prospectively registered (NCT03689504). Child growth and diet quality study outcomes have been reported separately.[30] StaRI reporting guidelines for implementation studies were used in the development of this manuscript.[31]

Context and Intervention Description

The study took place in San Andrés Semetebaj, Sololá, an agrarian Indigenous Maya municipality in the Western Highlands. Poverty and food insecurity are significant problems in Sololá, with a stunting prevalence of 66% of all children younger than 5 years.[32] The principal agricultural practices are maize-based subsistence agriculture,[33] and most agricultural land is not irrigated.[34] Water availability is a concern in the dry season (November through May).[35]

The garden intervention is described in detail in Figure 1. The home garden intervention provided families with seeds and seedlings for 16 different crops selected to bridge known micronutrient gaps in the local diet and garden construction materials, as well as eight educational and eight home visit technical assistance sessions with an agronomist. Participants were educated on the use of raised-bed square foot gardening, along with pits and containers for select crops. In addition, all families received a standard-of-care nutrition intervention, which provided families with access to five group nutrition classes, six one-on-one home visits with a community health worker for child growth assessment and individual counseling, multiple micronutrient powders (30 sachets per month), and food supplements (4 pounds of beans and 30 eggs per month). As designed, the intervention included a maximum of 13 agriculture and nutrition classes and 14 home visits for garden and standard-of-care nutrition support.

Intervention Participants

Households were eligible to participate if they had a child 6 to 24 months of age with stunting (length-for-age *Z*-score of ≤ -2.0). Households were recruited collaboratively with community and public health authorities, based on either concerning anthropometric measures taken during public health campaigns or needs-based referrals. Subsequently, family eligibility was confirmed on home visit by study staff. Eighty-nine households were screened, 78 were eligible, and 70 agreed to participate. Subsequently, five enrolled households voluntarily withdrew. Households that withdrew from the intervention were invited to complete follow-up data collection.

Data Sources and Instruments

An overview of study outcomes and data sources aligned with the RE-AIM framework is given in Figure 2. Surveys were developed by the study team through review of the literature, enumeration of all local crop species, and iterative field-testing. All data collection instruments are available in an online public repository.[36]

The sociodemographic and outcomes survey was collected at enrollment (n = 70 households) and 6-month follow-up (n = 69) by a trained, bilingual (Spanish/Mayan languages) research assistant. Sociodemographic questions included sex and age of the index child, maternal education level, language spoken, number of children in household, household food insecurity, poverty, and child length-for-age *Z*-score. Household food insecurity was measured using the Food Insecurity Experience Scale,[37] and poverty was assessed using the validated Simple Poverty Scorecard for Guatemala.[38] This survey also included an observational crop inventory, from which crop species count and nutritional functional diversity[39,40] were calculated, and yes/no questions asking participants about household consumption of cultivated crops. A separate agriculture survey was collected before building the household garden ~1 month after enrollment (n = 68 households) and 5 months after enrollment (n = 59) by a bilingual study agronomist. This survey involved direct observation of key gardening practices, garden maintenance, and the success or failure of crops.

Fidelity checklists for core components of the educational and technical support visits were developed by the field supervisor and a research fellow and refined and implemented with

Garden inputs	Seeds and seedlings for 16 different crops. Families could pick from 20 crops selected for being sources of priority micronutrient and macronutrient gaps in rural Guatemala (iron, vitamin A, vitamin C, folate, and protein): carrot, broccoli, red pepper, beets, onion, jalapeño pepper, radish, zucchini, winter squash, green beans, Swiss chard, amaranth leaves, long-beak rattlebox, black nightshade, mint, cilantro, passion fruit, tomatillo, tree tomato, fava beans. On average, 5 oz of carrot seeds, 10 broccoli seedlings, 10 bell pepper seedlings, 45 beet seeds, 10 long-beak rattlebox plants, 10 black nightshade seedlings, 50 amaranth seeds, 20 chard seeds, 45 onion seedlings, 10 jalapeño pepper seedlings, 10 green bean seeds, 800 radish seeds, 2 cilantro plants, 2 mint plants, 4 fava bean seeds, 2 zucchini seeds, and 2 tomato tree plants were provided at enrollment.
Garden construction materials	6 wooden boards, 1 pound of nails, 1.5 pounds of plastic rope, 17 yards of chicken wire, 150 pounds of leaf litter, and 100 pounds of composted cow manure.
Additional inputs	Gray water filter to assist with recycling water for irrigation.
One-on-one home visits	8 monthly, individualized home visits by an agronomist to provide technical assistance and coaching for weeding; how to plant, get rid of pests, and irrigate; when to harvest; and best practices for seed saving and garden maintenance.
Agriculture classes	8 group or individual classes delivered by the agronomist using a standardized curriculum on the importance of a home garden, square foot gardening, raised bed construction, garden maintenance, seed saving, composting, use of nurseries, harvesting, and pest management.
[a]More detailed intervention methodology and technical documentation are available at https://doi.org/10.7910/DVN/JFJGNY.[36] This documentation includes: determination of nutrient gaps and selection of appropriate local crop species, didactic materials for agriculture visits and classes, and agriculture technical manual (including gray water filter construction).	

Figure 1. Details of home garden intervention received by participating households in rural Guatemala[a]

input from the two senior investigators. Field supervisors used checklists to audit 5% of visits before March 2020. In addition, completion of visits was documented in the electronic study registry and used to assess overall attendance.

Semistructured interviews and focus groups were conducted by the research fellow with the assistance of a trained K'iche' Maya interpreter. Four implementing staff and three community stakeholders were interviewed, and two focus groups were conducted with three household participants each. These were carried out in August to September 2019 (near the midpoint of the total study timeline). Households that participated in the focus groups were halfway through the study intervention. Interview and focus group guides were developed iteratively by members of the research team and are available for review in an online public repository.[36] Interviews occurred in Spanish or K'iche' Maya based on participant preferences. All sessions were recorded, and summary statements were given after each session to allow participants to make final comments or corrections. The average session was 58 minutes for staff interviews, 48 minutes for community interviews, and 81 minutes for focus groups. Transcribed recordings were imported into DeDoose for coding and analysis.[41]

Intervention costs were assessed by examining bookkeeping entries provided by Maya Health Alliance accounting staff. The project had a dedicated institutional ledger and bank account facilitating this analysis. Direct project costs (eg, costs associated with garden construction materials, staff salaries, transportation) and monitoring and evaluation costs were assessed.

Overall Study Timeline

Figure 3 summarizes an overall study timeline. Households were enrolled in a rolling fashion (roughly 7 households per month) between January 17, 2019 and November 30, 2019. Face-to-face intervention activities and face-to-face data collection and auditing were suspended in March 2020 with the onset of the COVID-19 pandemic. At this point, all gardens were already installed, and remaining activities included education sessions, assistance with garden maintenance, and completion of surveys. When possible, these activities were completed over the phone. All previously observed data points (crop inventory, gardening practices and maintenance, and crop success/failure) were therefore now self-reported by participants. Overall, 15% of intervention visits, 18% of sociodemographic and outcomes follow-up surveys, and 36% of agricultural follow-up surveys occurred virtually. Final data collection for the last enrolled households concluded in July 2020.

Data Analysis

Quantitative data were analyzed using Stata[42] and R.[43] Descriptive statistics for quantitative outcomes were summarized using means and standard deviations or medians and interquartile ranges (continuous variables) and percentages (categorical variables). Raw Food Insecurity Experience Scale and Simple Poverty Scorecard scores were converted to household probabilities of experiencing moderate-to-severe food insecurity or living below the national poverty line, respectively. Change in crop species diversity was calculated as the difference in the raw sums of all edible crops in the household from enrollment to 6-month follow-up. Crop count data were used to calculate nutritional functional diversity, a measure of the total nutrient

RE-AIM Element	Measures	Instrument or data source	Timing	Responsible staff
Reach	Proportion of screened and eligible households participating	Electronic study registry	Monitored throughout study	Study staff
	Attrition rate	Electronic study registry	Monitored throughout study	Study staff
	Proportion of prospective households reached	Municipal data	End of study	Study staff
	Demographic characteristics of participating households	Sociodemographic and outcomes survey with intervention participants	Study enrollment	Trained research assistant
	Perceptions of reach	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
Effectiveness	Crop inventory[a] and reported consumption	Sociodemographic and outcomes survey with intervention participants	Study enrollment and 6 months after enrollment[b]	Trained research assistant
	Perceptions of effectiveness	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
	Unintended negative consequences	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
Adoption	Proportion of approached communities who participate	Staff documentation	Monitored throughout study	Study staff
	Barriers to adoption	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
Implementation	Delivery of intervention visits	Electronic study registry	Monitored throughout study[c]	Study staff
	Fidelity of intervention visits	Observational fidelity checklist	Completed for 5% of intervention visits through March 2020[d]	Study supervisor

(continued on next page)

Figure 2. RE-AIM based measures and data sources for a home garden intervention in rural Guatemala

RE-AIM Element	Measures	Instrument or data source	Timing	Responsible staff
	Agricultural practices adopted by participants	Agriculture survey with intervention participants	Before building study garden (1 month after enrollment) and 5 months after enrollment[b]	Study agronomist
	Adaptations	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
	Facilitators and barriers to implementation	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow
	Intervention costs	Finance records	End of study	Accounting staff, study staff
	Failure rate of crops	Agriculture survey with intervention participants	5 months after enrollment[b]	Study agronomist
Maintenance	Perceived sustainability challenges	Interviews with community stakeholders and study staff and focus groups with intervention participants	August–September 2019 (study midpoint)	Research fellow

[a]Used to calculate crop species count and nutritional functional diversity.

[b]Staff observed these measures when conducting the survey in-person. After March 2020 (onset of COVID-19 pandemic), measures were reported by participants via phone.

[c]Intervention visits delivered via phone after March 2020.

[d]Fidelity monitoring suspended in March 2020.

Figure 2. *(continued)* RE-AIM based measures and data sources for a home garden intervention in rural Guatemala

Timeframe	Activity
April 2017–December 2018	Development of gardening technical materials, gray water filter design, community recruitment.
January 2019	Rolling recruitment of households and baseline data collection begins.
March 2019	First gardens planted.
March 2020	First COVID-19 case in Guatemala. Face-to-face intervention activities suspended. Data collection suspended.
April 2020	Data collection and educational activities resume via phone. Garden quality and intervention fidelity now self-reported by participants.
July 2020	Virtual educational and data collection activities for last participating households completed.

Figure 3. Intervention timeline for a home gardening intervention in rural Guatemala

diversity provided by crops.[39,40] For this study, nutritional functional diversity was calculated with values between 0 and 1 (lowest to greatest diversity), and change in nutritional functional diversity was calculated as the difference in this score from enrollment to 6-month follow-up. Changes in agricultural practices before and after the intervention were assessed using McNemar's χ^2 test. For cost analysis, ledger entries were aggregated into raw materials, other intervention costs (salaries, transportation, communication), and monitoring and evaluation categories. Total costs were expressed on a per-household basis.

For qualitative analysis, a small set of a priori codes were developed through consensus based on the RE-AIM dimensions. Subsequently, an inductive thematic analysis approach was used to develop additional codes and validate a priori codes.[44] All transcripts were double-coded in Spanish by two team members who independently open-coded a subset of four transcripts and then reviewed these open codes together, establishing a hierarchical organization of themes and merging them with a priori codes to establish the final coding scheme.[36] Inter-coder inconsistencies were resolved by discussion. Both primary coders were registered dietitians who received training in qualitative analysis and direct supervision from an experienced qualitative researcher.

RESULTS

Mixed-methods results are presented following the RE-AIM framework and indicators outlined in Figure 2.

Reach

Participation. Seventy-seven percent (70/89) of screened households and 90% (70/78) of eligible households participated in the intervention. The attrition rate for participating households was 7% (5/70), with a median length of 2 months between enrollment and withdrawal from the garden intervention. The two common reasons for declining to enroll or for withdrawal were time constraints or concerns about lack of available water for irrigation. Overall, the 70 enrolled households represent approximately 15% of the 475 households in the recruitment areas of San Andrés Semetabaj.

Demographic Characteristics of Participating Households. Fifty-four percent of enrolled children were male, and 94% of households primarily spoke a Mayan language. The median age of the enrolled child was 376 days (interquartile range [IQR], 265-524), median maternal educational attainment was 6 years (IQR 3-8), and the median number of children per household was two (IQR 1-4). The median household probability of living below the poverty line was 90%, and the median probability of moderate to severe food insecurity was 69%. Per the intervention protocol, at least one child 6 to 24 months of age in each household was stunted at baseline, with a median length-for-age *Z*-score of −3.05 (IQR, −3.57, −2.68). There were no significant differences between the households that completed the interventions vs the five who withdrew (analysis not shown).

Perceptions of Reach. Although interest and participation in the garden intervention was high among households that were approached and enrolled, qualitative data indicated that many more were interested but unable to participate because of eligibility criteria requiring that participants have a child with stunting. Another barrier to reach was that underemployment and poverty caused some potential beneficiaries to be hesitant to participate, as reported by one community stakeholder:

> *Difficulties with motivation come from economics, and sometimes from the very poor conditions in which people live. Sometimes people here unfortunately are ashamed of other people seeing their homes. (Stakeholder 3)*

Effectiveness

Crop Species Count and Nutritional Functional Diversity. From baseline to 6-month follow-up, the number of crop species cultivated by participating households increased by five species (95% CI, 4-6), and the nutritional functional diversity of garden plots increased by 0.16 points (95% CI, 0.12-0.28). When restricting analysis to only those crops that the household self-reported regularly consuming, the crop count increased by two species (95% CI, 1-3) and nutritional functional diversity increased by 0.04 points (95% CI, 0.01-0.07). Figure 4 shows the top 10 crops cultivated by households at the 6-month follow-up. Among these commonly cultivated crops, the crops most frequently consumed were onions, black nightshade, jalapeño peppers, radishes, and chard. Selected crops with large gaps between cultivation and consumption included carrots, long-beak rattlebox, and beets.

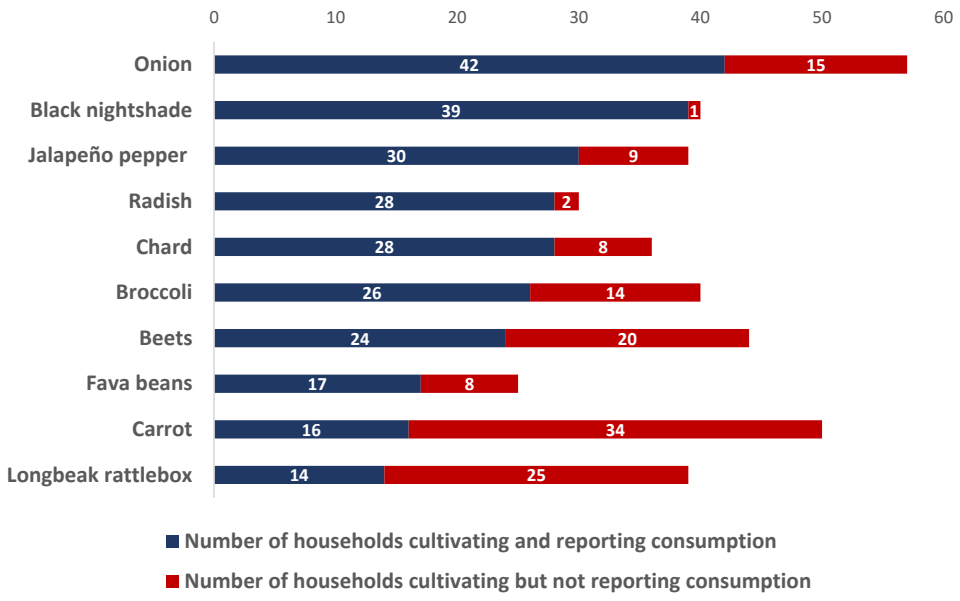

Figure 4. Household cultivation and reported consumption of selected garden crops 6 months after enrolling in a home garden intervention in rural Guatemala (n = 70 households). Data are shown for the top 10 crops cultivated by participating households.

Perceptions of Effectiveness. Household participants and community stakeholders both noted that the garden intervention improved access to diverse, affordable foods for participating households. For example, one participant (Focus Group 1) stated:

> *I think that in my family there have been changes because before if we bought a pound of green beans, we would finish it right away and there wouldn't be any for tomorrow.… In the garden, there are four squares [of green beans] and each one has two plants. If I want to go get some, I'll still have some for tomorrow, or even for next week.*

Similarly, a community stakeholder (Stakeholder 3) cited increased access, mentioning that:

> *[The intervention] has helped a lot, because the gardens, besides strengthening the defense systems of children and families, help in various ways economically…. [Participants] don't need to go and buy vegetables. Because the gardens, when they're well cared for the way you guys train people, give a lot of harvest.*

Unintended Negative Consequences. Community stakeholders and staff noted that many families wanted to participate in the intervention but were not eligible because of the child stunting requirement, as noted above:

> *The people that are not participating…they would like to participate, but since they can't, sometimes the ladies become upset. So they say, "Why not us?" but we try to explain that it is because they don't have small children." (Stakeholder 1)*

Adoption

Communities Adopting the Intervention. Home gardening in rural Guatemala is dependent on buy-in from community leaders, because it uses community water resources for irrigation. In this regard, there was significant difficulty finding communities interested in participating because of concerns over water usage. The project team dedicated a significant amount of time to discussing the intervention with communities' leaders during the project design phase. From April 2017 to November 2018 serial meetings were held with community leaders from four candidate communities, and of these four, only one (San Andrés Semetebaj) authorized the project, with reassurances from the project team that a gray water filter to recycle household wastewater would be provided to each participating household.

Perceptions of Barriers to Adoption. As noted, difficulty negotiating water access was identified by program staff as a significant challenge during the project:

> *In most of the communities, [water] is a very delicate matter. We know that. But we have also considered those factors. In the dry season, we use a [gray water] filter. But up until now, given that it's the rainy season, there haven't been many complaints. The garden does not require daily or prolonged irrigation. So, I tell [the participants] that if water is very scarce, we can water twice a week. (Intervention Staff)*

Implementation

Delivery and Fidelity of Intervention Visits. Participants received a median of 10 of 13 (77%; IQR, 8–11) classes and 13 of 14 (93%; IQR, 10–14) home visits. During audits by supervisors, most components were reliably delivered, defined as occurring in more than 70% of visits. Four criteria were met less frequently. These were distribution of educational handouts (50%); hands-on involvement of participants in demonstration activities (40%); clearly stating objectives of visit (69%); and completion

Table 1. Frequency of agricultural practices employed by households participating in a home garden intervention in rural Guatemala at baseline[a] and follow-up[b]

Practice	Baseline (n = 68)	Follow-up (n = 59)	P[c]
Use of a nursery, n (%)	18 (26)	14 (24)	>0.99
Use of a fence to protect crops, n (%)	29 (43)	54 (92)	<0.01
Addition of new organic material, n (%)	22 (32)	38 (64)	<0.01
Use of mulch, n (%)	6 (9)	5 (8)	>0.99
Practice of saving fruit and vegetable seeds, n (%)	23 (34)	31 (53)	0.09
Practice of staggered planting, n (%)	3 (4)	48 (81)	<0.01
Use of natural sprays to control pests, n (%)	1 (1)	16 (27)	<0.01
Practice of removing pests by hand, n (%)	19 (28)	31 (53)	0.02
Use of repellent plants, n (%)	1 (1)	2 (4)	0.5
Practice of intercropping to control pests, n (%)	0 (0)	53 (90)	<0.01
Practice of crop rotation to control pests, n (%)	0 (0)	2 (4)	0.5

[a]Before building gardens (~1 month after enrollment).
[b]5 months after enrollment.
[c]Based on McNemar's χ^2.

of visits within the planned time limit (62%).

Adoption of Agricultural Practices by Participants. One hundred percent of households (59 of 59) used raised beds, 98% (58 of 59) used pits, and 12% (7 of 59) used containers. Table 1 shows the percentage of households who employed key agricultural practices at baseline and 6-month follow-up. At follow-up, more than half of the participants were using fencing ($P < 0.01$), adding organic material ($P < 0.01$), saving seeds ($P = 0.09$), using staggered planting ($P < 0.01$), removing pests by hand ($P = 0.02$), and practicing intercropping ($P < 0.01$). Less commonly adopted practices included use of a nursery, mulching, use of repellent plants, and crop rotation. In addition, participants reported spending a median of 2 (IQR, 1–3) days per week working in their gardens. For most (69%), work sessions were less than 1 hour in length.

Adaptations. Important programmatic adaptations identified in interviews and focus groups (before the onset of the COVID-19 pandemic) included giving individualized rather than group classes to accommodate participants' schedules, rescheduling programmatic activities around participants' needs, shortening the length of classes and home visits, and modifying eligibility criteria to reach more families. In August 2019, the threshold child length-for-age *Z*-score for entry into the program was changed from ≤−2.5 to ≤−2.0 to allow for more households to be reached.

Another important adaptation was the development of a gray water filter using locally available materials so that participants could use recycled water for garden irrigation. Development of this filter facilitated participation of San Andrés Semetebaj after leaders expressed concerns about public water use. One community stakeholder also noted that some participants started collecting rainwater for irrigation, a practice that was not taught as part of the intervention.

Perceptions of Barriers and Facilitators to Implementation. Ongoing technical support from the agronomist was consistently seen by study participants and staff as necessary for successful implementation of the intervention. For example, a participant (Focus Group 1) noted:

> *The [agronomist] visits have helped us, because as the others were saying, there are plants that don't grow or that die, and [the agronomist] finds the solution.*

Other facilitators included the provision of seeds and wood, the use of locally accessible materials, a common culture shared between staff and participants, and small garden size, which minimized requirements for space and labor.

Time constraints were the most cited implementation barrier, given caregivers' other responsibilities such as working outside the home and attending to children. For this reason, the flexibility of program staff to accommodate participant's schedules was important:

> *For me, on some occasions I couldn't attend [classes], given that I have other crops and I live by myself. It was tough for me timewise, the day and the hour. "I'm going to rearrange my schedule to help you," the agronomist tells me, and he gives me classes individually. (Participant, Focus Group 1)*

Intervention Costs. Total per-beneficiary costs for the 65 households that completed the home garden intervention are shown in Table 2. The materials cost per household was $102.21, whereas other direct program costs, including salary and transportation, totaled $660.70 per household. An additional $376.03 per household was spent on monitoring and evaluation.

Failure Rate of Crops. Three crops used in the project had failure rates greater than 25%. These were jalapeño

Table 2. Per-household intervention costs for a home garden intervention in rural Guatemala (n = 70 households)[a]

Cost Category	Amount (USD[b])
Direct Project Costs: Raw Material Costs	
Organic matter	46.46
Wood for raised beds	16.86
Seeds/seedlings	13.39
Fencing materials	9.24
Gray water filter materials	8.03
Garden tools	1.31
Other supplies	6.91
Subtotal	102.21
Direct Project Costs: Other Intervention Costs[c]	
Intervention staff salaries	
Nutrition technician	108.10
Agronomist	231.12
Telecommunications	11.08
Misc. equipment/supplies	7.22
Transportation	
Public transit	11.88
Vehicle acquisition	217.20
Vehicle maintenance	56.46
Fuel	17.64
Subtotal	660.70
Total Direct Costs Per Household	762.91
Monitoring and Evaluation Costs[c]	
Staff salary	120.26
Volunteer compensation	4.67
Telecommunications	5.54
Miscellaneous equipment/supplies	7.22
Transportation	
Vehicle acquisition	177.71
Vehicle maintenance	46.19
Fuel	14.44
Subtotal	376.03
Total Costs Per Household	1138.94

[a]Costs were incurred over approximately a 6-month timeframe for each household within the entire project period (January 17, 2019 to July 31, 2020).
[b]USD = United States dollar.
[c]These per-household costs are dependent on the number of households enrolled in the study.

peppers (40%), beets (33%), and red bell peppers (26%). The study agronomist determined that the causes of failure included higher maintenance requirements for these crops as well as need for more direct sunlight (peppers) and water (beets).

Maintenance

Perceived Sustainability Challenges.

Community stakeholders, staff, and intervention participants noted two major sustainability challenges. First, many elements required for the intervention were provided by Maya Health Alliance, including seeds and manual labor for garden construction. Striking a balance with more inputs provided by participants was thought to be important for continuing the project:

> *The final objective is for them to be able to do this with what [materials] they have, so it doesn't suit us to say, "We will provide everything," if they don't contribute anything. (Intervention Staff)*

Second, the ability of participants to access replacement seeds was a challenge. Concerns about participants' ability to source, purchase, or distribute seeds independently of Maya Health Alliance were expressed by all. For example, a community stakeholder (Stakeholder 1) commented:

> *In the beginning, everything was going well. But I have heard that after they are given [seeds], the families then have to purchase them. There I see that there are families that have the resources to buy [seeds] and other families that don't.*

Many interviewees suggested that participant-led seed distribution initiatives and seed saving were important solutions.

DISCUSSION

This study evaluated the implementation of a home garden intervention in rural Guatemala using a mixed-methods approach and the RE-AIM framework. As intended, the intervention reached food-insecure and impoverished families with children who were stunted. Families that participated in the intervention had poverty and food insecurity characteristics similar to those of other families in the region.[45] The intervention was valued by participants and community stakeholders and led to diversified household crop production. Evaluation activities identified crops with high consumption and low failure rates as well as others that were poorly consumed or failed at a high rate. Participants were able to maintain their gardens at a high level with a time investment of approximately 2 hours per week. The procurement of seeds, intervention cost, and water access were important limiting factors for sustainability. This study contributes to a growing body of implementation research on home gardens, with

particular relevance to the Guatemalan context.

Impact of Water Access on Program Reach

Together with previous research in other settings, this study highlights how the reach of home garden interventions is limited in communities without ready access to water. For example, an integrated agriculture, health, and behavior change program in Burkina Faso excluded more than 25% of otherwise eligible villages because of lack of access to water in the dry season, and several villages did not participate because buy-in from local authorities could not be obtained because of the politics surrounding shared water usage.[46] The reach of garden interventions could be improved through carefully integrated water conservation strategies, as has been demonstrated by the Helen Keller Institute for their programs in Burkina Faso.[14] The gray water filter developed for this project could improve local authority buy-in for future garden projects in Guatemala.

Impact of Eligibility on Program Reach

The eligibility criteria for this project, which were tied to the standard-of-care nutrition intervention designed for children with stunting, had an unintended negative impact on community perceptions of the intervention. Along these lines, Nordhagen et al[8] found, in studying the implementation of agriculture projects in four sub-Saharan African countries, that narrow targeting can lead to perceptions of inequity for those excluded and decrease buy-in.[8] This is an important consideration for program designers and funders, because there is increasing interest in focusing interventions on critical periods such as the first 1,000 days.[47] In communities with high prevalence of food insecurity and poverty, nutrition risk may be community-wide, and highly targeted programs may be mismatched with community needs.

Gaps Between Crop Production and Consumption

Increased household crop diversity is an important mediator of the nutritional impact for garden interventions. Like many studies conducted in other settings,[40,48] this garden intervention increased crop diversity. Unexpectedly, however, some of the cultivated crops were self-reported as not consumed. Although these self-reported metrics might be underestimated, other likely reasons for the gap include (1) slower-than-expected growth of some plants, such that they were not ready for harvest at the follow-up assessment and therefore not yet consumed; (2) overharvesting of some crops, causing them to stop producing; and (3) participants' lack of experience with processing some crops, leading to delayed harvesting or wastage.

These explanations reflect the reality that for more than 70% of participating households in this intervention, home gardening was a new practice. In rural Guatemala, agrarian households are primarily focused on maize-based agriculture.[49] Although native greens, squash, and beans are often intercropped with maize, home vegetable gardens are not ubiquitous. The only vegetables commonly cultivated by households for consumption before this intervention were jalapeño peppers, winter squash, and black nightshade.[50] By contrast, in Bangladesh, where home gardens have been intensively promoted since at least the early 1990s, a 2016 study found that a home garden intervention increased produce production from 85 kg to 109 kg annually at follow-up, with the bulk being consumed within the home.[16] The implication of these contrasting scenarios is that, depending on local familiarity with home gardening, greater or lesser degrees of follow-up and technical support will be required to ensure optimal crop consumption. Recommendations for ongoing maintenance of this project include the development of recipes to share with households that include all crops being grown in the garden, and especially the less familiar ones.

Impact of Participant Time Constraints on Program Delivery

Although overall participation rates and adoption of key gardening practices were high throughout the intervention, multiple changes were required to reduce participant time burden, including flexible visit scheduling by staff, shortened class durations, and delivering content that was originally intended for group classes one-on-one. Evaluations of other homestead food production programs have also noted time constraints as a limiting factor.[10,13,14] Economically vulnerable women in low- and middle-income countries are oftentimes faced with the triple burden of childcare, domestic work, and agricultural labor.[51] Intervention staff primarily interacted with female caregivers, and involving adult male household members or other adult members of the household more substantially in the future will be important for sustainability.

Sustainability: Costs of Labor and Garden Inputs

Transportation and staff salary costs were by far the largest expenses for this intervention. This is because, given the low overall baseline exposure to home gardening, intensive agronomist inputs were needed to support participants. In future work, more detailed cost–benefit analyses will be of value. In addition, embedding local agronomy experts who live within participating communities could reduce travel costs and allow for more frequent contacts with participants. Involvement of the Government of Guatemala's agricultural extension service may be another way to reduce costs.

Organic matter represented a substantial percentage of garden material costs. Longer-term strategies to enhance soil fertility, such as composting, could decrease reliance on external sources of organic matter.[52] Seed and seedlings procurement were the greatest sustainability challenge, because obtaining some types of seeds required traveling long distances and was essentially only feasible because the project had a dedicated agronomist who could work as an intermediary with distributors. In Nepal, several studies have reported that seed saving and exchange are important mechanisms by which farmers procured vegetable seeds and maintained home gardens.[53,54] Building participants' technical capacity for seed saving or collective seed distribution efforts is a critical sustainability measure.[8]

Strength and Limitations of the Current Work

This implementation evaluation examined each aspect of the RE-AIM

framework using mixed methods, yielding pragmatic recommendations that can be used to improve future garden interventions in Guatemala. A major limitation was the use of several survey instruments developed within the project (eg, to assess crop production and intervention fidelity), which limits comparison with garden studies from other regions. Additional limitations include the small number of households involved, and the restricted geographic focus of the project, limiting generalizability. Additionally, the COVID-19 pandemic forced the collection of some data virtually, which may have compromised data quality, limited ability to assess fidelity later in the intervention, and prohibited assessment of long-term outcomes.

CONCLUSIONS

This mixed-methods implementation study evaluated barriers and facilitators for a home garden intervention in rural Guatemala using the RE-AIM implementation framework, and it contributes to a growing body of implementation knowledge on this topic. There are several ways in which future garden interventions in the Guatemalan context could be modified to improve acceptability, effectiveness, sustainability, and scalability. Garden interventions should carefully consider program eligibility criteria and identify context-specific needs and solutions related to crop selection, water access, technical assistance, and availability of seeds and seedlings.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

SA, EYJ, and PR designed the evaluation framework and instruments. SA and AG oversaw the data collection. SA and GVP conducted interview coding. SA, AG, GVP, EYJ, and PR analyzed and interpreted the data. SA wrote the first draft of the manuscript. All authors reviewed and commented on subsequent drafts of the manuscript.