Academy of Nutrition and Dietetics Nutrition Research Network: A Home Garden Intervention Improves Child Length-for-Age Z-Score and Household-Level Crop Count and Nutritional Functional Diversity in Rural Guatemala

Andrea Guzmán-Abril, BS, LN; Stephen Alajajian, BS, RDN; Peter Rohloff, PhD, MD; Gabriela V. Proaño, MS, RDN; Jennifer Brewer, MA, RDN; Elizabeth Yakes Jimenez, PhD, RDN, LD

ABSTRACT

Home gardens may help address childhood malnutrition in low- and middle-income countries. In this quasi-experimental pilot study, the Academy of Nutrition and Dietetics, in collaboration with Maya Health Alliance, evaluated the feasibility of augmenting a standard-of-care nutrition-specific package for Maya children with length-for-age *z* score ≤ -2 (stunting) in rural Guatemala with a nutrition-sensitive home garden intervention. Two agrarian municipalities in Guatemala were included. Families of 70 children with stunting from 1 municipality received the standard-of-care package (food supplementation, multiple micronutrient powders, monthly nutrition home visits, group nutrition classes). Families of 70 children with stunting from another municipality received the standard-of-care package plus a home garden intervention (garden materials, monthly agricultural home visits, agriculture classes). Maternal and child dietary diversity, household food insecurity, child growth, and agricultural indicators were collected at baseline and 6 months later and were analyzed using mixed linear and logistic regression models. Compared with the standard-of-care group, the garden intervention group had improved child (odds ratio [OR] 3.66, 95% CI 0.89-15.10, $P = 0.07$) and maternal dietary diversity (OR 2.31, 95% CI 0.80-6.65, $P = 0.12$) and decreased food insecurity (OR 0.38, 95% CI 0.11-1.35, $P = 0.14$); however, these effects were not statistically significant. Participation in gardens predicted a higher length-for-age z-score (change difference [CD] 0.22 SD, 95% CI 0.05-0.38, $P = 0.009$), greater crop species count (CD 2.97 crops, 95% CI 1.79-4.16, $P < 0.001$), and greater nutritional functional diversity (CD 0.04 points, 95% CI 0.01-0.07, $P = 0.006$) than standard-of-care alone. Home garden interventions are feasible in rural Guatemala and may have potential benefits for child growth when added to other nutrition-specific interventions.

J Acad Nutr Diet. 2021;■(■):■-■.

Supplementary materials: The Supplementary File is available at www.jandonline.org.

CHILDREN IN GUATEMALA ARE at high nutritional risk, with a 47% prevalence of stunting (low length/height-for-age, or chronic malnutrition) in children under age 5 nationally.[1,2] The rural indigenous Maya population is disproportionately affected by food insecurity and malnutrition, with a prevalence of stunting as high as 70% in some communities.[1,2] Only around half of Guatemalan children under 2 years of age receive a minimum acceptable diet according to World Health Organization criteria that assess whether the child is being fed an adequate variety of food groups (minimum dietary diversity) and whether the child is being fed often enough (minimum feeding frequency).[2,3] Children's diets generally contain adequate protein and energy, but are typically monotonous, with a high proportion of carbohydrates and limited animal-source foods.[4] The typical diet is deficient in multiple micronutrients, especially zinc and iron.[4] The reasons for these child stunting and diet quality outcomes in Guatemala are complex, but include rising costs of basic food staples, decreasing pools of available land for subsistence agriculture due to rising population, low minimum wages and widespread informal employment arrangements, and discrimination and racism against the Maya population.[5-8]

https://doi.org/10.1016/j.jand.2021.04.002

Stunting is a complex problem with proximal, underlying, and root causes, and it is associated with an increased risk for morbidity and mortality from acute infectious illnesses in childhood, developmental and cognitive delays, and increased lifelong risk for non-communicable chronic diseases.[5,8] Underlying and root causes of stunting extend beyond nutrition into areas such as agriculture, education, and poverty.[9] Nutrition-specific interventions alone, which address only proximal, directly nutrition-related causes, have had limited effectiveness in many settings. A multisectoral approach including both nutrition-sensitive interventions (targeting underlying causes) and nutrition-specific interventions is necessary to successfully address stunting.[9,10] However, a recent scoping review found that only nutrition-specific strategies, focusing mostly on dietary supplementation and improvement of complementary feeding practices, have been evaluated in Guatemala.[11] The National Strategy for the Prevention of Chronic Malnutrition in Guatemala advocates for the adoption of nutrition-sensitive strategies, including water and sanitation and agriculture and livestock programs,[12] but evidence is still lacking for their effectiveness in the Guatemalan context.

Home gardens have long formed an integral part of food production systems in low- and middle-income countries.[13] There is growing interest in home gardening as a nutrition-sensitive strategy to promote food security and to improve child nutrition outcomes.[13] Numerous studies have been conducted in low- and middle-income countries to evaluate the impact of home gardening when paired or integrated with nutrition education and other nutrition-specific interventions.[14-18] Such interventions can improve household food security and dietary diversity and lead to improved vitamin A and iron intakes among children,[19] but evidence of impact on child growth outcomes is mixed. Furthermore, few such studies have been conducted in Latin America, and specifically in Guatemala, despite the fact that agriculture is a major economic activity in Guatemala, with 70% of families working in agriculture, mainly as subsistence farmers and growers of export crops.[20]

To address these evidence gaps, the Academy of Nutrition and Dietetics' Nutrition Research Network collaborated with Maya Health Alliance, a primary health care organization specializing in nutrition interventions in Guatemala, to conduct a pilot study. The objective of this pilot study was to determine the feasibility of evaluating, in a larger, adequately powered trial, whether augmenting an existing, standard-of-care nutrition-specific intervention package for children with stunting in rural Guatemala with a nutrition-sensitive home garden intervention would lead to improvements in maternal and child dietary diversity, household food insecurity, child growth, and agricultural indicators compared with the standard-of care alone. It was hypothesized that the addition of home gardens to the standard-of-care would lead to improvements in each of these outcomes. This pilot study aligns directly with the Academy's mission to accelerate improvements in global health and well-being through food and nutrition and the Academy principle focused on having a global impact in eliminating all forms of malnutrition.[21]

Standard-of-care nutrition intervention (received by both groups for 6 mo)	
Food supplementation	4 lb of beans/mo 30 eggs/mo
Multiple micronutrient powders	Powder micronutrient units containing vitamin A (300 μg), vitamin C (30 μg), folic acid (160 μg), iron (12.5 mg), and zinc (5 mg), 30/mo
One-on-one home visits	6 monthly one-on-one home visits by a community health worker to assess child diet and growth and provide individualized counseling to improve child diet diversity and meal frequency
Nutrition classes	5 group classes by a community health worker on nutrition during pregnancy, breastfeeding, complementary feeding, dietary diversity, stunting, and anemia
Home garden intervention (received by the intervention group only for 8 mo)	
Garden inputs	Seeds and seedlings for 16 different crops. Families could pick from 20 crops selected for being sources of iron, vitamin A, vitamin C, folate, and protein: carrot, broccoli, red pepper, beets, onion, spicy chile, radish, zucchini, green bean, swiss chard, amaranth, longbreak rattlebox, black nightshade, peppermint, passion fruit, miltomate, tree tomato, fava beans
Garden construction materials	Garden construction materials: 6 wooden boards, 1 lb of nails, 1.5 lb of plastic rope, 17 yards of chicken wire, 150 lb of leaf litter, and 100 lb of cow manure
One-on-one home visits	8 monthly home visits by an agronomist to provide technical assistance for weeding and coaching on how to plant, when to harvest, how to get rid of pests, how to irrigate, and best practices for seed saving and garden maintenance
Agriculture classes	8 group or individual classes by agronomist 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

Figure 1. Description of nutrition and gardening interventions in a home garden pilot study

METHODS

This pilot study examined the feasibility and potential effectiveness of adding a home garden intervention to an existing standard-of-care nutrition-specific intervention for children with stunting that was implemented from January 17, 2019, to July 31, 2020. The study design was quasi-experimental, with families from 1 municipality in Maya Health Alliance's catchment area receiving the home garden plus standard-of-care intervention (intervention group) and families from a different municipality receiving the standard-of-care intervention alone (standard-of-care group). The 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). Informed consent was provided by participants. The study was prospectively registered (ClinicalTrials.gov: NCT03689504). The Transparent Reporting of Evaluations with Nonrandomized Designs checklist was used in preparing the manuscript.[22]

Participants and Setting

Two participating municipalities were selected pragmatically by Maya Health Alliance leadership based on the following criteria: (a) high prevalence of stunting; (b) staff already providing standard-of-care nutrition intervention in the area; and (c) predominantly agricultural. Intervention assignment was done at the municipal level because of concerns about potential ethical and logistical difficulties with assigning individual households to the intervention within communities. Of the 2 participating municipalities, authorities in San Andrés Semetebaj in the Department of Sololá were willing to permit use of community water resources for irrigation and so families ($n = 70$) there were enrolled in the intervention group. Families ($n = 70$) in Tecpán in the Department of Chimaltenango were enrolled in the standard-of-care group. Both communities have a similar prevalence of stunting and economic profile, and Maya Health Alliance community health workers routinely deliver nutrition services to families living in small clusters surrounding the municipal center in both communities.

Potentially eligible families were identified through the regular growth monitoring activities of Maya Health Alliance and public health posts. Families were eligible to participate if they had at least 1 child aged 6 to 24 months who was stunted (length/height-for-age z score of ≤ -2.0).[10] Exclusion criteria included children with acute malnutrition (a weight-for-length z score of ≤ -2.0) or a severe medical illness that is known to affect growth (eg, congenital heart disease). Caregivers were approached by research staff in their homes to discuss potential participation and to obtain informed consent. There were no restrictions on relationship of the primary caregiver to the index child for purposes of enrollment; all primary caregivers in this study were women and the biological mother of the child.

Intervention Delivery

A summary of the components of the standard-of-care nutrition intervention and the home garden intervention is given in Figure 1. Briefly, the standard-of-care intervention included food rations, multiple micronutrient powder, group nutrition classes for caregivers, and monthly home visits to provide individualized growth monitoring and dietary assessment and counseling. These elements were provided by community health workers, who used standardized materials and were overseen by a nutritionist. The home garden intervention provided families with seeds and seedlings and garden construction materials, including boards, nails, plastic rope, chicken wire, leaf litter, and composted cow manure (estimated materials cost of US$102.21 per household). A staff member with a technical degree in agronomy and prior experience working with home gardens provided educational and home visit sessions to assist with garden construction and maintenance (salary and transportation costs estimated to be US$660.70 per household).

Given the nature of the interventions, neither research staff nor participant blinding was feasible. All home visits and classes were provided in the caregiver's preferred language. Classes were held in groups of no more than 10 women. Home nutrition visits lasted 45 to 60 minutes, and nutrition classes lasted 60 to 120 minutes. Agriculture home visits and classes lasted 30 to 60 minutes and were designed considering existing agricultural practices within communities, accessibility of gardening materials, and familiarity with crops in the study region. Monthly field monitoring of the home visits and classes was carried out by study supervisors to monitor the fidelity of intervention delivery, such as coverage of key educational topics and elements of garden construction and maintenance. After the onset of the COVID-19 pandemic in March 2020, home visit and class content were delivered individually to families via telephone. This impacted 74 households (52.9% of study total). Thirty-two families did not receive a second planned delivery of seeds in May 2020 due to movement restrictions and community-imposed roadblocks.

Data Collection

Data were collected at baseline and 6 months later. The original study protocol planned to follow subjects for 12 months, with baseline measures and outcome measures at 6 and 12 months. However, due to challenges with data collection after the onset of the COVID-19 pandemic in March 2020, the study was shortened to only include 6-month follow-up.

Primary outcomes for the study were maternal and child dietary diversity and household food insecurity, and secondary outcomes included child growth, crop species count, and nutritional functional diversity score. Dietary diversity was assessed using the Minimum Dietary Diversity for Women indicator for caregivers[23] and the World Health Organization Infant and Young Child Feeding Indicators[24] for children. Household food insecurity was measured using the Food Insecurity Experience Scale (FIES).[25] Child weight and length measurements were collected in triplicate by trained study nurses. Training procedures followed guidelines provided by the Institute of Nutrition of Central America and Panama.[26] Weight was measured to the nearest 0.1 kg using a 310 hanging scale (Seca) and length/height was measured to the nearest 0.1 cm with the use of a portable length board locally constructed according to United Nations International Children's Emergency Fund specifications.[27] A study-specific observational plant checklist was used to gather the information needed to calculate nutritional functional diversity and crop species count. In this study, both indicators considered only the crops that the household reported consuming. Monthly field monitoring of data collection was carried out by study supervisors using quality control checklists to evaluate implementation of study standard operating procedures for data collection. In addition to the primary and secondary outcomes, a standard questionnaire was used to gather basic sociodemographic information and maternal and child health history for each participant. This included the Simple Poverty ScoreCard, a survey measure validated in Guatemala that uses household size and demographics, home construction, and presence of common consumer goods to calculate the probability that a family lives below the national poverty line.[28] Questionnaires were completed in person with study participants until the onset of the COVID-19 pandemic in March 2020; starting at that point until the end of the study, all questionnaires were completed with participants over the telephone. Telephone-based data collection for questionnaires occurred with 74 households (52.9% of study total). Anthropometric measurements were not collected after the onset of the COVID-19 pandemic. As a result, end line anthropometric data are missing for some participants (35 households total [25% of total study sample], including 22 households in the intervention group and 13 households in the standard-of-care group). All data were collected on paper and digitized using double entry into REDCap[29] by 2 independent staff.

Sample Size

As a pilot study of feasibility and potential effectiveness of home gardening in this setting, no sample size calculation was performed. Target enrollment was 70 families per group based on available funds and staff capacity.

Data Processing

Minimum dietary diversity was defined as children receiving foods from at least 4 out of 7 defined food groups per day[24] and women consuming foods from at least 5 out of 10 defined food groups per day.[23] Probabilities of food insecurity were calculated from the FIES for the specific sample using the methodology of the Food and Agriculture Organization of the United Nations.[25] High food insecurity was defined as a raw score of 4 (corresponding to a 69% probability of moderate to severe food insecurity) or greater on the FIES. A raw score of 3 (corresponding to a 36% probability) or lower on the FIES was consider low food insecurity.

Child anthropometric *z* scores were calculated using the World Health Organization's Child Growth Standards.[30] The mean of the first 2 measurements was used if they did not differ by more than a prespecified tolerance limit (length/height $<$ 0.5 cm, weight $<$ 0.1 kg). If they differed more than these prespecified tolerance limits, the third measurement was compared with the first and second measurements and the pair of measurements that has the smallest difference was used to calculate the mean.

Crop species count was defined as the total number of observed edible plant species cultivated and consumed near the home. Nutritional functional diversity was calculated using the methodology of Petchey and Gaston.[31] A species by trait matrix was developed containing the nutrient levels of all possible crops for protein, calcium, iron, vitamin C, folate, vitamin A, zinc, thiamine, niacin, potassium, magnesium, vitamin B_6, and vitamin B_{12} using the Instituto De Nutrición De Centro America Y Panama Central America Food Composition Table.[32] Approximately 10% of data values were missing, and these were left unchanged as they were not expected to substantially impact pairwise distance calculations. Nutrient levels were expressed as percentages of recommended intakes sufficient to meet the needs of most healthy individuals, averaged between infants and children, provided by 100 g of the crop in the consumed form using Instituto De Nutrición De Centro America Y Panama daily dietary recommendations. Reference values for iron and zinc assumed they were coming from plant sources. Euclidean distances were calculated between each pair of crops on the basis of nutritional content to form a distance matrix. Unweighted pair group method with arithmetic mean was then used to cluster the crops into a functional dendrogram. The nutritional functional diversity for each homestead was calculated as a value between 0 (lowest nutritional functional diversity) and 1 (highest nutritional functional diversity) by dividing the total branch length of the resulting dendrogram by the total branch length of the dendrogram containing all theoretically possible species.

Statistical Methods

Stata version 14.0[33] was used for all analyses. Differences in baseline characteristics between study communities were tabulated and assessed using the Student *t* test, the Wilcoxon rank-sum test, and the χ^2 test as appropriate. Primary and secondary outcome variables were evaluated using mixed logistic or mixed linear regression models, as appropriate, with random effects for individuals to account for intrasubject correlation and clustering by community sector. For the primary study outcomes, we used mixed logistic regression to assess differences between groups in the change in meeting maternal minimum diet diversity ($\geq$5 food groups per day), in meeting minimum child diet diversity ($\geq$4 food groups per day) or in level of household food insecurity (high [score of $\geq$4 on the FIES] vs low) from 0 to 6 months. For the secondary study outcomes, we used mixed linear regression to assess differences between groups in changes in height/length-for-age *z* score, crop species count, and nutritional functional diversity from 0 to 6 months. All models included an interaction term for time $\times$ study group, which represented impact. Fixed effects included covariates and confounders chosen for inclusion based on expert knowledge of the local team, review of comparative nutrition literature, or a *P* value of $<$0.10 in bivariate analysis for baseline imbalances between the study communities. These included, with some variation based on outcome of interest: maternal years of education, poverty score calculated using the Simple Poverty Scorecard, number of children in the home, child sex and age, baseline child adequate dietary diversity (consumption of at least 4 of 7 food groups), baseline household high food insecurity (score of $\geq$4 on the FIES), and baseline crop count. Effect modification was tested by including an interaction term for sex of child and study group and for length-for-age *z* score and study group, for relevant dependent variables. Analysis was by intention to treat. Sensitivity analyses included per-protocol regression analysis and models with dummy variables included to indicate when outcome data were collected during the hunger season in Guatemala (mid-April through end of August)[34] or during the COVID-19 pandemic (to account for potential impact of COVID-19 on study outcomes and for differences in data collection methods during this time).

RESULTS

Subject Enrollment

A summary of study recruitment and retention is shown in Figure 2. Recruitment occurred in a rolling fashion from January to November 2019. In total, 140 children and their primary caregivers were enrolled into the standard-of-care (n = 70) and intervention (n = 70) groups. One hundred thirty-nine were included in the final analysis (n = 70 standard-of-care, n = 69 intervention). Five households in the intervention group (7% of those enrolled) voluntarily withdrew from the garden intervention before completing all agricultural activities but continued with data collection and standard-of-care activities. Decisions to withdraw were either due to time constraints for intervention activities or concerns about water availability for garden irrigation.

Baseline Characteristics

Selected descriptive characteristics of the 2 study communities are given in Table 1. Some differences between the communities existed at baseline. Maternal education was lower and the probability of household poverty higher in the standard-of-care group. Child diet quality was higher in the standard-of-care group, primarily because children had higher dietary diversity compared with the intervention group. Crop species were similar, but nutritional crop diversity was lower in the standard-of-care group.

Study Outcomes

Results from intention-to-treat mixed logistic and linear regression models for primary and secondary study outcomes are given in Tables 2 and 3, respectively. For all 3 primary outcomes, odds ratios favored the intervention group, indicating improved maternal and child diet quality and decreased food insecurity relative to the standard-of-care group, but 95% CIs were wide and the results were not statistically significant (Table 2).

On average, the intervention group had a length/height-for-age *z* score 0.22 standard deviations higher than the standard-of-care group (95% CI 0.05-0.38, $P = 0.009$). The intervention group also had a higher crop species count

Standard-of-care nutrition intervention (received by both groups for 6 months)	
Food supplementation	4 pounds of beans per month 30 eggs per month
Multiple micronutrient powders	Powder micronutrient units containing vitamin A (300ug), vitamin C (30ug), folic acid (160ug), iron (12.5mg), and zinc (5mg), 30 per month
One-on-one home visits	6 monthly one-on-one home visits by a community health worker to assess child diet and growth and provide individualized counselling to improve child diet diversity and meal frequency
Nutrition classes	5 group classes by a community health worker on nutrition during pregnancy, breastfeeding, complementary feeding, dietary diversity, stunting and anemia
Home garden intervention (received by the intervention group only for 8 months)	
Garden inputs	Seeds and seedlings for 16 different crops. Families could pick from 20 crops selected for being sources of iron, vitamin A, vitamin C, folate and protein: carrot, broccoli, red pepper, beets, onion, spicy chile, radish, zucchini, green bean, swiss chard, amaranth, longbreak rattlebox, black nightshade, peppermint, passion fruit, miltomate, tree tomato, fava beans
Garden construction materials	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 cow manure
One-on-one home visits	8 monthly home visits by an agronomist to provide technical assistance for weeding, coaching on how to plant, when to harvest, how to get rid of pests how to irrigate and best practices for seed saving and garden maintenance.
Agriculture classes	8 group or individual classes by agronomist 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.

Figure 2. Participant flow diagram for a quasi-experimental home garden study conducted in Guatemala.

Table 1. Selected baseline demographic and clinical characteristics of participants in the standard-of-care and intervention groups of a home garden pilot study

Characteristic	Intervention (n = 70)	Standard of care (n = 70)	P value[a]
Household characteristics			
Children living in home, n, median (25th, 75th percentile)	2 (1,4)	2 (2, 5)	0.18
Raw food insecurity score, median (25th, 75th percentile)[b]	4 (1,5)	2 (0,4)	0.09
Raw poverty score, median (25th, 75th percentile)[c]	27 (20, 37)	16 (12, 25)	<0.01
Child characteristics			
Child age, days, median (25th, 75th percentile)	376 (265,524)	343 (259,471)	0.28
Female sex, %	46	41	0.61
Birthweight, kg, median (25th, 75th percentile)	2.95 (2.72, 3.29)	2.72 (2.72, 3.18)	0.18
Length-for-age Z score, median (25th, 75th percentile)	−3.05 (−3.57, −2.68)	−3.20 (−3.7, −2.68)	0.64
Weight-for-age Z score, median (25th, 75th percentile)	−1.55 (−2.07, −1.25)	−1.58 (−2.23, −1.07)	0.85
Weight-for-length Z score, median (25th, 75th percentile)	0.18 (−0.30,0.75)	0.32 (−0.18, 0.86)	0.60
Age of complementary foods introduction, months, median (25th, 75th percentile)	6 (6,7)	6 (6,7)	0.94
Meets minimum dietary diversity, %	54	74	.01
Meets minimum meal frequency, %	87	89	.80
Meets acceptable diet, %	49	69	.02
Caregiver characteristics			
Education, y, median (25th, 75th percentile)	6 (3,8)	3 (0, 4)	<0.01
Prefers Mayan language, %	94	97	0.40
Meets minimum dietary diversity for women, %	61	69	0.54
Home Agriculture Practices			
Unique species crop count[d], n, median (25th, 75th percentile)	9 (6,10)	9 (7,11)	0.43
Nutritional functional diversity of crops, median (25th, 75th percentile)[e]	0.21 (0.17, 0.25)	0.18 (0.12, 0.24)	0.04

[a]For all continuous and ordinal variables, Wilcoxon rank-sum test was used to calculate *P* value and medians (25th, 75th percentile) are presented. For categorical variables, the χ^2 test was used to determine *P* values.
[b]A raw score of 4 on this scale corresponds to a 69% probability of moderate to severe food insecurity; lower scores are indicative of less food insecurity.
[c]A raw score of 25-29 corresponds to an 87% probability of living below the national poverty line; lower scores are indicative of more poverty.
[d]Number of unique edible crops cultivated near the home and consumed by the household diverseity.
[e]A measure of the nutrient diversity provided by the assemblage of unique edible crops cultivated near the home and consumed by the household, on a scale from 0 to 1 (least to most nutrient diversity).

(change difference 2.97 species, 95% CI 1.79-4.16, $P < 0.001$) and improved nutritional functional diversity of crops cultivated (change difference 0.04, 95% CI 0.01-0.07, $P = 0.006$) compared with the standard-of-care group.

For all outcomes, no effect modification by child sex or baseline length-for-age *z* score was observed. None of the sensitivity analyses conducted changed the interpretation of the study results, including per-protocol analyses and adjustment for seasonality and the start of the COVID-19 pandemic (Supplementary File, available at www.jandonline.org).

DISCUSSION

This quasi-experimental study demonstrated that home garden interventions may have potential benefit when added to other nutrition-specific interventions, particularly in terms of improving child linear growth and household access to a variety of produce in rural Guatemala. The study findings, combined with a low attrition rate, serve as proof of concept for including home gardens as part of an effective multisectoral package for child malnutrition in rural Guatemala, as called for by the Government of Guatemala's national strategy to combat chronic malnutrition.[12] As with all quasi-experimental studies, the effectiveness findings from this study should be interpreted cautiously, and there is a need for ongoing program evaluation and additional rigorously designed research studies to understand the impact of home gardens in the Guatemalan context. In addition, there is a need to examine the sustainability of home garden implementation and effectiveness over longer periods of time, which had been intended with this study but was not possible due to the onset of the COVID-19 pandemic.

In other settings, home garden interventions have been shown to improve maternal and child dietary diversity and measures of food insecurity.[19] For example, a participant-led intervention in Kenya that included poultry rearing and kitchen gardening increased the proportion of children meeting minimum child dietary diversity by 23% (95% CI 11%-36%) ($P < 0.001$) compared with a pair-matched control.[17] Another large,

Table 2. Results from mixed logistic regression models for primary study outcome variables in a quasi-experimental home garden study conducted in Guatemala

Study outcome	Child minimum diet diversity[a] (n = 139)	Maternal minimum diet diversity (n = 139)[bc]	Food insecurity (n = 139)[d]
Fixed effects			
Variable	←——— OR[e] (95% CI)[f] ———→		
Time × study group (intervention)[g]	3.66 (0.89-15.10)	2.31 (0.80-6.65)	0.38 (0.11-1.35)
Time (6-mo follow-up)	2.87 (1.10-7.53)*	0.76 (0.37-1.57)	0.67 (0.27-1.62)
Study group (intervention)	0.30 (0.12-0.77)*	0.47 (0.16-1.41)	4.44 (1.40-14.04)*
Maternal education, y	1.01 (0.90-1.12)	1.07 (0.97-1.20)	1.02 (0.89-1.17)
Baseline poverty score[h]	1.01 (0.97-1.04)	1.02 (0.99-1.05)	0.95 (0.91-0.99)*
Baseline food insecurity (high)[d]	1.34 (0.66-2.73)	1.86 (1.01-3.41)*	—[i]
Baseline adequate child dietary diversity[b]	—[i]	—[i]	0.82 (0.33-2.02)
Sex of child (male)	1.07 (0.56-2.05)	1.28 (0.74-2.20)	0.95 (0.42-2.14)
Age of child, d	2.59 (1.26-5.32)**	1.41 (0.80-2.45)	3.28 (1.32-8.16)*
Baseline crop count	—[i]	—[i]	1.10 (0.97-1.25)
Random effects			
Community sector	0.000 (n/a)	0.10 (0.001-7.55)	0.000 (n/a)
Participant[j]	0.21 (0.000-187.04)	0.09 (0.000-1084.48)	2.24 (0.77-6.52)

[a]According to World Health Organization Infant and Young Child Feeding Indicators. Met if the child consumed 4 of 7 food groups.
[b]According to the Minimum Dietary Diversity in Women Scale. Met if the woman consumed 5 of 10 food groups.
[c]The overall fixed-effects model for Minimum Dietary Diversity in Women was not significant ($P = 0.154$).
[d]Using the Food Insecurity Experience Scale. Considered high for raw scores of 4 and greater (possible range 0-8).
[e]OR = odds ratio.
[f]*P* values are from the corresponding regression models.
[g]Reflects the impact of the intervention.
[h]Based on Simple Poverty ScoreCard.
[i]Selected variables not included in these regression models when measuring the same dimension as outcome variable or because they were not associated with the outcome in bivariate analysis.
[j]Random effect of participant is included to account for intra-subject correlation.
*$P < 0.05$.
**$P < 0.01$.

cluster-randomized controlled trial in Tanzania that provided women in the intervention villages with agricultural training and materials and nutrition and public health counseling observed significant improvements in women's dietary diversity compared with the control group, with women in the intervention vs the control group consuming 0.50 (95% CI [0.20-0.80], $P = 0.001$) more food groups per day and being 14 percentage points (95% CI [6-22], $P = 0.001$) more likely to consume at least 5 food groups per day.[35] In this study, improvements in these outcomes were found for home garden participants compared with standard care, but they did not reach statistical significance, potentially due to a small sample size and the quasi-experimental design. Nevertheless, the findings provide preliminary estimates of potential impact for a larger, well-controlled trial. Additionally, this study adds to a small body of literature employing nutritional functional diversity as an indicator of crop diversity.[36,37] Nutritional functional diversity provides more information about the nutritional quality of foods available to and consumed by households than crop count alone and may be worthy of consideration as an indicator in future home garden trials. More research is needed to understand the relationship between nutritional functional diversity and clinical outcomes, such as child growth and micronutrient status.[37]

The effect of home gardens on child growth in the present study was similar to that reported by Marquis et al (0.22 SD increase, 95% CI [0.09-0.34]) in a cluster-randomized controlled trial of a 12-month integrated nutrition and agriculture program in Ghana.[38] In both cases, the agricultural intervention slowed the rate of decline of length/height-for-age z-scores compared with the comparison group, rather than improving *z* scores over time. This trial differed from ours in that the integrated program was compared against no intervention, a livestock component was included, and children were not necessarily stunted at baseline. The present study may have observed a similar effect despite some of these relative disadvantages because it specifically included only children with stunting at baseline. Some prior studies, including cluster-randomized controlled trials in Burkino Faso and Nepal with a more rigorous design than this study, have not observed improvements in child length-for-age *z* scores from home garden programs.[14,19,39,40] In a recent systematic review and meta-analyses examining the impact of interventions conducted in Africa and Asia that provided training and/or inputs for home gardens or poultry farming on several child health outcomes, Bassey et al noted that home food production interventions may increase length/height-for-age in intervention vs control children, although a bigger effect

Table 3. Results from mixed linear regression models for secondary study outcome variables in a quasi-experimental home garden study conducted in Guatemala

Study outcome	Length-for-age *z* score[a] (n = 137)	Crop count (n = 138)[b]	Nutritional functional diversity (n = 136)[c]
Fixed effects			
Variable	←Coefficient (95% CI)[d]→		
Time × study group (intervention)[e]	0.22 (0.05-0.38)**	2.97 (1.79-4.16)***	0.04 (0.01-0.07)**
Time (6-month follow-up)	−0.22 (−0.33 to −0.11)***	−0.81 (−1.65-0.03)	−0.01 (-0.27-0.01)
Study group (intervention)	−0.09 (−0.38-0.20)	−1.58 (−3.24-0.08)	0.003 (−0.58-0.06)
Maternal education, years	0.01 (−0.03-0.05)	0.04 (−0.11-0.19)	0.001 (−0.003-0.004)
Baseline poverty score[f]	0.004 (−0.01-0.02)	−0.004 (−0.05-0.04)	−0.0001 (−0.001-0.001)
Baseline food insecurity[g] (high)	0.10 (−0.15-0.36)	0.54 (−0.37-1.44)	0.01 (−0.01-0.03)
Number of children in home	—[h]	—[h]	−0.002 (−0.01-0.003)
Baseline adequate child dietary diversity[i]	−0.16 (−0.42-0.10)	0.20 (−1.12-0.72)	−0.01 (−0.03-0.01)
Sex of child (male)	0.11 (−0.35-0.12)	−0.27 (−1.11-0.58)	−0.02 (−0.05-0.002)
Age of child, days	0.14 (−0.11-0.39)	0.64 (−0.25-1.53)	0.01 (−0.01-0.03)
Random effects			
Community sector	0.000 (n/a[j])	0.37 (0.01-11.94)	0.001 (0.000-0.004)
Participant[k]	0.43 (0.33-0.56)	2.92 (1.64-5.19)	0.001 (0.000-0.002)

[a]According to World Health Organization growth standards. Two outliers were excluded. Follow-up data were available for only 105 subjects. Endline anthropometric data were missing for 22 households in the intervention group and 13 households in the standard-of-care group because in-person data collection had to be stopped after the onset of the COVID-19 pandemic in March 2020.
[b]One outlier was excluded.
[c]Three outliers were excluded.
[d]*P* values are from the corresponding regression models.
[e]Reflects the impact of the intervention.
[f]Based on the Simple Poverty ScoreCard.
[g]Using the Food Insecurity Experience Scale. Considered high for raw scores of 4 and greater (possible range 0-8).
[h]This variable was not included in these models because it was not associated with the outcome in bivariate analysis.
[i]According to World Health Organization Infant and Young Child Feeding Indicators. Met if the child consumed at least 4 of 7 food groups.
[j]n/a = not available.
[k]Random effect of participant is included to account for intra-subject correlation.
**$P < 0.01$.
***$P < 0.001$.

was observed in studies that combined home gardening and poultry farming vs studies that focused on home gardening alone.[41] These mixed findings may be the result of several factors. Home food production interventions can be quite heterogenous,[40] and implementation barriers and causes of stunting[8] vary across settings. Therefore, efforts to address childhood stunting through household production diversity strategies merit further investigation in each context.

Among the strengths of this study are that the intervention was designed to accommodate local agricultural realities, the intervention was delivered in participants' preferred languages, and the results reflect the impact of home gardening alone without a livestock component. Important limitations should also be acknowledged. First, as a pilot study with a quasi-experimental design, the sample size was small, and there were some baseline imbalances between the 2 study groups, which were clustered in separate communities. We attempted to address this through an adjusted analysis using mixed regression models, but with such a small number of communities involved, there may have been differences that could not be fully adjusted for using a statistical model that could explain the observed results. The intervention group also had more overall contact time with staff compared with the standard-of-care group, which may have increased motivation to adopt both the nutrition-specific and nutrition-sensitive aspects of the study. In addition, the onset of the COVID-19 pandemic resulted in some missing outcome data and shortened the planned duration and evaluation of the intervention from 12 to 6 months, limiting our ability to detect longer-term benefits. As the missing outcome data were due to the COVID-19 pandemic, which affected the ability to conduct in-person visits with all participants regardless of any individual- or household-level characteristics, we do not believe this would have caused a systematic bias that would affect the interpretation of the results. In addition to disrupting our study operations, the COVID-19 pandemic in rural Guatemala has caused worsening unemployment and household finances, rising food costs, and worsening food insecurity, potentially impacting outcome data that were collected after March 2020.[42] For outcomes that were able to be collected via telephone after the onset of the COVID-19 pandemic, we conducted a sensitivity analysis to explore possible effects of COVID-19, via altered data collection methods or altered household socioeconomic status and food access, and there was no significant impact on the interpretation of the study results. Finally, self-reported dietary diversity and household food security data are subject to social desirability bias. We mitigated this to an extent by using a standard-of-care comparison group and by training the study nurse to administer surveys in a nonjudgmental manner.

CONCLUSIONS

In a quasi-experimental pilot study, adding home gardening to an existing nutrition-specific intervention for children with stunting in rural Guatemala led to improvements in child height/length-for-age z score and home crop production. This study serves as proof of concept for multicomponent nutrition-sensitive and nutrition-specific interventions in rural Guatemala, in alignment with the national strategy for combatting child stunting. Future work will seek to validate results from the pilot in a larger, well-controlled trial.

References

1. Ministerio de Salud Pública y Asistencia Social (MSPAS), Instituto Nacional de Estadística (INE), Secretaría de Planificación y Programación de la Presidencia (Segeplán). Informe Final: VI Encuesta Nacional de Salud Materno Infantil 2014-2015. The Demographic and Health Surveys Program. Published January 2017. Accessed March 22, 2021. https://www.dhsprogram.com/pubs/pdf/FR318/FR318.pdf
2. United States Agency for International Development. Guatemala: nutrition profile. Updated February 2018. Accessed March 22, 2021. https://www.usaid.gov/sites/default/files/documents/1864/Guatemala-Nutrition-Profile-Mar2018-508.pdf
3. Martinez B, Cardona S, Rodas P, et al. Developmental outcomes of an individualised complementary feeding intervention for stunted children: A substudy from a larger randomised controlled trial in Guatemala. *BMJ Paediatr Open*. 2018;2(1):1-9. https://doi.org/10.1136/bmjpo-2018-000314
4. FANTA. Development of evidence-based dietary recommendations for children, pregnant women, and lactating women living in the western highlands in Guatemala. Published June 2014. Accessed March 22, 2021. https://www.fantaproject.org/sites/default/files/resources/Guatemala-Optifood-June2014.pdf
5. Dewey KG, Begum K. Long-term consequences of stunting in early life. *Matern Child Nutr*. 2011;7(Suppl 3):5-18. https://doi.org/10.1111/j.1740-8709.2011.00349.x
6. Méthot J, Bennett EM. Reconsidering non-traditional export agriculture and household food security: A case study in rural Guatemala. *PLoS One*. 2018;13(5). 2018;e0198113. https://doi.org/10.1371/journal.pone.0198113
7. Brown K, Henretty N, Chary A, et al. Mixed-methods study identifies key strategies for improving infant and young child feeding practices in a highly stunted rural indigenous population in Guatemala. *Matern Child Nutr*. 2016;12(2):262-277. https://doi.org/10.1111/mcn.12141
8. World Health Organization (WHO). Stunted growth and development: context, causes and consequences. Published 2017. Accessed March 22, 2021. https://www.who.int/nutrition/childhood_stunting_framework_leaflet_en.pdf?ua=1
9. Ruel MT, Alderman H. Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? *Lancet*. 2013;382(9891):536-551. https://doi.org/10.1016/S0140-6736(13)60843-0
10. Hossain M, Choudhury N, Adib Binte Abdullah K, et al. Evidence-based approaches to childhood stunting in low and middle income countries: a systematic review. *Arch Dis Child*. 2017;102(10):903-909. https://doi.org/10.1136/archdischild-2016-311050
11. Cordon A, Asturias G, De Vries T, Rohloff P. Advancing child nutrition science in the scaling up nutrition era: A systematic scoping review of stunting research in Guatemala. *BMJ Paediatr Open*. 2019;3(1):1-9. https://doi.org/10.1136/bmjpo-2019-000571
12. Gobierno de la República de Guatemala. Gran Cruzada Nacional por la Nutrición. Secretaría de Seguridad Alimentería y Nutricional (SESAN). Published 2020. Accessed March 22, 2021. http://www.sesan.gob.gt/wordpress/wp-content/uploads/2020/04/Documento-tecnico-Gran-Cruzada-Nacional_17HD.pdf
13. Galhena DH, Freed R, Maredia KM. Home gardens: A promising approach to enhance household food security and wellbeing. *Agric Food Secur*. 2013;2:8. https://doi.org/10.1186/2048-7010-2-8
14. Olney DK, Pedehombga A, Ruel MT, Dillon A. A 2-year integrated agriculture and nutrition and health behavior change communication program targeted to women in Burkina Faso reduces anemia, wasting, and diarrhea in children 3-12.9 months of age at baseline: A cluster-randomized controlled trial. *J Nutr*. 2015;145:1317-1324. https://doi.org/10.3945/jn.114.203539
15. Olney DK, Bliznashka L, Pedehombga A, Dillon A, Ruel MT, Heckert J. A 2-year integrated agriculture and nutrition program targeted to mothers of young children in Burkina Faso reduces underweight among mothers and increases their empowerment: a cluster-randomized controlled trial. *J Nutr*. 2016;146(5):1109-1117. https://doi.org/10.3945/jn.115.224261
16. Osei AK, Pandey P, Spiro D, et al. Adding multiple micronutrient powders to a homestead food production programme yields marginally significant benefit on anaemia reduction among young children in Nepal. *Matern Child Nutr*. 2015;11:188-202. https://doi.org/10.1111/mcn.12173
17. Boedecker J, Odhiambo Odour F, Lachat C, Van Damme P, Kennedy G, Termote C. Participatory farm diversification and nutrition education increase dietary diversity in Western Kenya. *Matern Child Nutr*. 2019;15(3):e12803-e12803.
18. Michaux KD, Hou K, Karakochuk CD, et al. Effect of enhanced homestead food production on anaemia among Cambodian women and children: A cluster randomized controlled trial. *Matern Child Nutr*. 2019;15(Suppl 3):e12757.
19. Ruel MT, Quisumbing AR, Balagamwala M. Nutrition-sensitive agriculture: What have we learned and where do we go from here? International Food Policy Research Institute. Published October 2017. Accessed March 22, 2021. https://www.ifpri.org/publication/nutrition-sensitive-agriculture-what-have-we-learned-and-where-do-we-go-here
20. Bouroncle C, Imbach P, Läderach P, et al. La agricultura de Guatemala y el cambio climático: ¿Dónde están las prioridades para la adaptación? CGIAR Research Program on Climate Change, Agriculture and Food Security. Published 2015. Accessed March 22, 2021. https://ccafs.cgiar.org/es/resources/publications/la-agricultura-de-guatemala-y-el-cambio-climatico-donde-estan-las
21. Academy of Nutrition and Dietetics. Academy mission, vision and principles. Accessed March 22, 2021. https://www.eatrightpro.org/about-us/academy-vision-and-mission/mission-and-vision-statements
22. Jarlais D, Don C. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: The TREND statement. *Am J Public Health*. 2004;94(3):361-366.
23. FAO. Food and Agriculture Organization of the United Nations (FAO) and FHI 360. Minimum dietary diversity for women: A guide to measurement. Published 2016. Accessed March 22, 2021. http://www.fao.org/3/i5486e/i5486e.pdf
24. World Health Organization. Indicators for assessing infant and young child feeding practices: Part II Measurement. Published 2010. Accessed March 22, 2021. https://www.who.int/maternal_child_adolescent/documents/9789241599290/en/
25. Food and Agriculture Organization of the United Nations (FAO). Implementing the Food Insecurity Experience Scale (FIES) in surveys. Published 2018. Accessed March 22, 2021. http://www.fao.org/3/ca1454en/CA1454EN.pdf
26. Instituto De Nutrición De Centro America Y Panama (INCAP). Guía técnica para la estandarización en procesamiento, análisis e interpretación de indicadores antropometricos según los patrones de crecimiento de OMS para menores de 5

años. Sustainable Development Goals Fund. Published May 2012. Accessed March 22, 2021. https://www.sdgfund.org/sites/default/files/ISAN_GUIA_El%20Salvador_Patrones%20de%20Crecimiento.pdf

27. UNICEF. Target product profile: Height/length measurement device(s). Updated October 2017. Accessed March 22, 2021. https://www.unicef.org/supply/media/1291/file/Target%20product%20profile%20(TPP):%20Height%20length%20measurement%20device.pdf
28. Schreiner M. Simple Poverty Scorecard ® Poverty-Assessment Tool Guatemala. Published October 2016. Accessed March 22, 2021. http://www.simplepovertyscorecard.com/GTM_2014_ENG.pdf
29. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)-A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381. https://doi.org/10.1016/j.jbi.2008.08.010
30. World Health Organization (WHO). Child growth standards: WHO Anthro Survey Analyser and other tools. Accessed March 22, 2021. https://www.who.int/tools/child-growth-standards/software
31. Petchey OL, Gaston KJ. Functional diversity (FD), species richness and community composition. *Ecol Lett*. 2002;5(3):402-411. https://doi.org/10.1046/j.1461-0248.2002.00339.x
32. Instituto De Nutrición De Centro America Y Panama (INCAP), Organización Panamericana de la Salud (OPS). Tabla Composición de Alimentos de Centroamérica. Published February 2012. Accessed March 22, 2021. http://www.incap.int/mesocaribefoods/dmdocuments/tablacalimentos.pdf
33. *Stata*. Version 14.0. StataCorp; 2015.
34. Gobierno de la República de Guatemala. Plan para la Mitigación de los Efectos del Hambre Estacional 2018. Secretaría de Seguridad Alimenteria y Nutricional (SESAN). Published 2018. Accessed March 22, 2021. http://www.siinsan.gob.gt/siinsan/wp-content/uploads/Plan-para-la-Mitigacion-de-los-Efectos-del-Hambre-Estacional-2018.pdf
35. Blakstad MM, Mosha D, Bellows AL, et al. Home gardening improves dietary diversity, a cluster-randomized controlled trial among Tanzanian women. *Matern Child Nutr*; 2020. 2020;e13096. https://doi.org/10.1111/mcn.13096
36. Luna-González DV, Sørensen M. Higher agrobiodiversity is associated with improved dietary diversity, but not child anthropometric status, of Mayan Achí people of Guatemala. *Public Health Nutr*. 2018;21(11):2128-2141.
37. Remans R, Flynn DFB, DeClerck F, et al. Assessing nutritional diversity of cropping systems in African villages. *PLoS One*. 2011;6(6): 2011;e21235. https://doi.org/10.1371/journal.pone.0021235
38. Marquis G, Colecraft EK, Kanlisi R, et al. An agriculture−nutrition intervention improved children's diet and growth in a randomized trial in Ghana. *Matern Child Nutr*. 2018;14(Suppl S3): 2018;e12677. https://doi.org/10.1111/mcn.12677
39. Osei A, Pandey P, Nielsen J, et al. Combining home garden, poultry, and nutrition education program targeted to families with young children improved anemia among children and anemia and underweight among nonpregnant women in Nepal. *Food Nutr Bull*. 2017;38(1):49-64. https://doi.org/10.1177/0379572116676427
40. Girard AW, Self JL, McAuliffe C, Olude O. The effects of household food production strategies on the health and nutrition outcomes of women and young children: A Systematic Review: Household food production and maternal and child health outcomes. *Paediatr Perinat Epidemiol*. 2012;26:205-222. https://doi.org/10.1111/j.1365-3016.2012.01282.x
41. Bassey C, Crooks H, Paterson K, et al. Impact of home food production on nutritional blindness, stunting, wasting, underweight and mortality in children: A systematic review and meta-analysis of controlled trials. *Crit Rev Food Sci Nutr*:1-14. https://doi.org/10.1080/10408398.2020.1848786 (epub ahead of print).
42. Integrated Food Security Phase Classification (IPC). Guatemala: Acute Food Insecurity Situation August - October 2020 and Projection for November 2020−March 2021. Accessed March 22, 2021. http://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1152911/?iso3=GTM

AUTHOR INFORMATION

A. Guzman-Abril is a licensed nutritionist and study manager, Wuqu' Kawoq, Alianza Maya Para la Salud, Tecpán, Guatemala. S. Alajajian is an Applied Global Nutrition Research Fellow, Academy of Nutrition and Dietetics Foundation, Chicago, IL. P. Rohloff is chief medical officer, Wuqu' Kawoq, Alianza Maya Para la Salud, Tecpán, Guatemala. G. V. Proaño is a research project manager, Academy of Nutrition and Dietetics, Chicago, IL. J. Brewer is a nutrition consultant (private practice) and cochair, Global Member Interest Group, Academy of Nutrition and Dietetics, Chicago, IL. E. Y. Jimenez is director, Nutrition Research Network, Academy of Nutrition and Dietetics, and research associate professor, Departments of Pediatrics and Internal Medicine and College of Population Health, University of New Mexico Health Sciences Center, Albuquerque, NM.

Address correspondence to: Elizabeth Yakes Jimenez, PhD, RDN, LD, 120 S. Riverside Plaza, Suite 2190, Chicago, IL 60606-6995.120 S. Riverside PlazaSuite 2190ChicagoIL60606-6995 E-mail: bjimenez@eatright.org

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING/SUPPORT

This study was supported by funding from the Academy of Nutrition and Dietetics Foundation. The Academy of Nutrition and Dietetics provided Nutrition Research Network staff support for technical assistance related to study design, implementation, and data analysis and interpretation, and mentoring of A. Guzmán-Abril and S. Alajajian. Funding to build the family gardens was provided by Rotary International.

ACKNOWLEDGEMENTS

We are grateful to Johana Raquec, Estela Xoquic, Vilma Borón, Eddy Roquel, and Kelly Wilson for their contributions to this project.

AUTHOR CONTRIBUTIONS

A. Guzmán-Abril, P. Rohloff, G. V. Proaño, J. Brewer, and E. Y. Jimenez developed the research idea and study design. A. Guzmán-Abril, S. Alajajian, and P. Rohloff supervised data collection and delivery of the intervention. A. Guzmán-Abril, S. Alajajian, P. Rohloff, and E. Y. Jimenez analyzed and interpreted the data. A. Guzmán-Abril wrote the first draft of the manuscript. All authors reviewed and commented on subsequent drafts of the manuscript.

SUPPLEMENTARY FILE: TABLE OF CONTENTS

SENSITIVITY ANALYSIS: PER-PROTOCOL ANALYSIS (DROPOUTS EXCLUDED)

Independent Variables

comunidad = community

id = household identification number

grupo_experimental = experimental group

escolaridad = maternal education

puntaje_pobreza =raw poverty score

inseguridad_base = food insecurity at baseline

sexo = sex of child

conteo_de_cultivos_base = crop out at baseline

diverisdad_ninos_base = child dietary diversity at baseline

gumshoes = number of children

escasez = season hunger

virtual = data collected during the COVID-19 pandemic

Dependent Variables

diversidad_minima_nino = minimum child dietary diversity

diversidad_minima_mujer = minimum dietary diversity in women

inseguridad = food insecurity

haz = length for age *z* score

Child Minimum Dietary Diversity

Mixed-effects logistic regression   Number of obs = 268

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	44.7	128
id	134	2	2.0	2

Integration method: mvaghermite   Integration pts. = 7

Wald chi2(8) = 22.82

Log likelihood = -122.65938   Prob > chi2 = 0.0036

diversidad_minima_nino	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	2.892099	1.428468	2.15	0.032	1.098467	7.614462
grupo_experimental						
Experimental	.3126524	.1528624	-2.38	0.017	.1199199	.81514
time#grupo_experimental						
1#Experimental	3.301053	2.398852	1.64	0.100	.7944933	13.7156
escolaridad	.986409	.0557999	-0.24	0.809	.882888	1.102068
puntaje_pobreza	1.006967	.0178099	0.39	0.695	.9726588	1.042486
inseguridad_base	1.503458	.5615468	1.09	0.275	.7230438	3.126209
sexo	1.012852	.3409491	0.04	0.970	.5236154	1.959205
edad	2.919185	1.103448	2.83	0.005	1.391581	6.123712
_cons	1.601863	.7731195	0.98	0.329	.6220187	4.125222
comunidad						
var(_cons)	1.62e-38	3.14e-21			.	.
comunidad>id						
var(_cons)	.1854109	.7388802			.0000752	457.3557

LR test vs. logistic model: chibar2(01) = 0.07   Prob >= chibar2 = 0.3960

Minimum Dietary Diversity in Women

Mixed-effects logistic regression   Number of obs   =   268

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	44.7	128
id	134	2	2.0	2

Integration method: mvaghermite   Integration pts. =   7

Wald chi2(8)   =   11.95
Log likelihood = -162.89226   Prob > chi2   =   0.1535

diversidad_minima_mujer	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.2700853	.3687326	-0.73	0.464	-.9927879	.4526174
grupo_experimental						
Experimental	-.7359788	.4225596	-1.74	0.082	-1.56418	.0922229
time#grupo_experimental						
1#Experimental	.8071713	.5449406	1.48	0.139	-.2608925	1.875235
escolaridad	.0628476	.0487482	1.29	0.197	-.0326972	.1583923
puntaje_pobreza	.0137977	.0146071	0.94	0.345	-.0148316	.0424271
inseguridad_base	.6530549	.3062456	2.13	0.033	.0528246	1.253285
sexo	.1742921	.2760431	0.63	0.528	-.3667424	.7153267
edad	.3945697	.2820506	1.40	0.162	-.1582393	.9473788
_cons	-.1117149	.4152883	-0.27	0.788	-.9256649	.7022352
comunidad						
var(_cons)	2.80e-34	1.91e-18			.	.
comunidad>id						
var(_cons)	.0638092	.4177764			1.71e-07	23874.36

LR test vs. logistic model: chibar2(01) = 0.02   Prob >= chibar2 = 0.4376

Food Insecurity

```
Mixed-effects logistic regression               Number of obs     =        268

-------------------------------------------------------------
                |     No. of       Observations per Group
 Group Variable |     Groups    Minimum    Average    Maximum
----------------+--------------------------------------------
      comunidad |          6         10       44.7        128
             id |        134          2        2.0          2
-------------------------------------------------------------

Integration method: mvaghermite                 Integration pts.  =          7

                                                Wald chi2(9)      =      18.29
Log likelihood = -151.88705                     Prob > chi2       =     0.0319
------------------------------------------------------------------------------------------
            inseguridad | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------------------+-----------------------------------------------------------------
                        |
                 1.time |   .6509825   .3044013    -0.92   0.359     .2603424    1.627772
                        |
      grupo_experimental |
           Experimental |   4.957749   3.208176     2.47   0.013     1.394663    17.62381
                        |
time#grupo_experimental |
         1#Experimental |   .2787656   .1930446    -1.84   0.065     .0717437    1.083165
                        |
            escolaridad |   1.033409   .0803647     0.42   0.673     .8873137    1.203559
        puntaje_pobreza |   .9484598   .0243243    -2.06   0.039     .9019634    .9973532
                   sexo |   .9076278   .4213545    -0.21   0.835     .3653831    2.254588
                   edad |   3.381493   1.757778     2.34   0.019     1.220771    9.366616
   diversidad_nino_base |   .8837009   .4577785    -0.24   0.811     .3201565    2.439205
conteo_de_cultivos_base |   1.113334    .081553     1.47   0.143     .9644373    1.285219
                  _cons |   .2018794   .1995393    -1.62   0.105     .0290909    1.400963
------------------------+-----------------------------------------------------------------
comunidad               |
              var(_cons)|   2.30e-32   5.58e-17                              .           .
------------------------+-----------------------------------------------------------------
comunidad>id            |
              var(_cons)|   2.969676   1.552635                         1.0658    8.274515
------------------------------------------------------------------------------------------
LR test vs. logistic model: chibar2(01) = 11.77       Prob >= chibar2 = 0.0003
```

Length-for-Age *z* Score

Mixed-effects ML regression — Number of obs = 231

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	5	38.5	118
id	132	1	1.8	2

Wald chi2(9) = 19.88
Log likelihood = -195.28836 — Prob > chi2 = 0.0186

haz	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.2193352	.0565976	-3.88	0.000	-.3302646	-.1084059
grupo_experimental						
Experimental	-.0546371	.1531203	-0.36	0.721	-.3547473	.2454732
time#grupo_experimental						
1#Experimental	.226014	.0846695	2.67	0.008	.0600649	.3919631
escolaridad	.0076807	.0207944	0.37	0.712	-.0330756	.0484371
puntaje_pobreza	.0033766	.0063942	0.53	0.597	-.0091559	.0159091
inseguridad_base	.071009	.131584	0.54	0.589	-.1868908	.3289089
diversidad_nino_base	-.1552969	.1384135	-1.12	0.262	-.4265823	.1159885
sexo	-.0770546	.1238246	-0.62	0.534	-.3197464	.1656372
edad	.1090225	.1314661	0.83	0.407	-.1486463	.3666913
_cons	-3.228539	.1859332	-17.36	0.000	-3.592961	-2.864116

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	3.72e-17	1.06e-15	2.25e-41	6.17e+07
id: Identity				
var(_cons)	.4327348	.0743868	.3089589	.6060979
var(Residual)	.0894724	.0136876	.0662935	.1207555

LR test vs. linear model: chi2(2) = 111.07 — Prob > chi2 = 0.0000

Crop Count

Mixed-effects ML regression   Number of obs = 266

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	44.3	128
id	133	2	2.0	2

Wald chi2(9) = 31.12
Log likelihood = -668.96342   Prob > chi2 = 0.0003

conteo_de_cultivos_consum	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.8115942	.428823	-1.89	0.058	-1.652072	.0288835
grupo_experimental						
Experimental	-1.396736	.856995	-1.63	0.103	-3.076415	.2829439
time#grupo_experimental						
1#Experimental	2.936594	.6181785	4.75	0.000	1.724987	4.148202
escolaridad	.0309588	.0767284	0.40	0.687	-.119426	.1813437
puntaje_pobreza	-.0087978	.0229298	-0.38	0.701	-.0537393	.0361438
inseguridad_base	.4959598	.4675594	1.06	0.289	-.4204397	1.412359
diversidad_nino_base	-.2936343	.4850772	-0.61	0.545	-1.244368	.6570996
sexo	-.2932501	.4392018	-0.67	0.504	-1.15407	.5675695
edad	.6756913	.4650058	1.45	0.146	-.2357034	1.587086
_cons	7.970778	.8644172	9.22	0.000	6.276552	9.665005

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	.365919	.6563033	.0108815	12.30493
id: Identity				
var(_cons)	2.935002	.8792608	1.631577	5.279701
var(Residual)	6.344176	.7779729	4.988778	8.067822

LR test vs. linear model: chi2(2) = 15.80   Prob > chi2 = 0.0004

Nutritional Functional Diversity

Mixed-effects ML regression — Number of obs = 262

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	43.7	128
id	131	2	2.0	2

Wald chi2(11) = 19.90
Log likelihood = 335.75641 — Prob > chi2 = 0.0468

diversidad_funcional_consum	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.0069561	.0103066	-0.67	0.500	-.0271567	.0132444
grupo_experimental						
Experimental	.0084629	.0308904	0.27	0.784	-.0520811	.0690069
time#grupo_experimental						
1#Experimental	.0385929	.0149815	2.58	0.010	.0092297	.067956
sexo						
Masculino	-.0221726	.0128211	-1.73	0.084	-.0473014	.0029563
sexo#grupo_experimental						
Masculino#Experimental	.0356755	.0184995	1.93	0.054	-.0005829	.0719339
escolaridad	.0008523	.0016925	0.50	0.615	-.002465	.0041696
puntaje_pobreza	-.0000902	.0005181	-0.17	0.862	-.0011057	.0009252
inseguridad_base	.0113485	.0098269	1.15	0.248	-.0079118	.0306088
diversidad_nino_base	-.0149088	.0100836	-1.48	0.139	-.0346723	.0048546
sexo	0	(omitted)				
edad	.0078236	.0097597	0.80	0.423	-.0113052	.0269523
num_hijos	-.0009635	.0023443	-0.41	0.681	-.0055584	.0036313
_cons	.1727187	.0297759	5.80	0.000	.1143591	.2310783

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	.0008135	.0006207	.0001823	.0036292
id: Identity				
var(_cons)	.0007222	.0003954	.000247	.002112
var(Residual)	.0036648	.0004528	.0028766	.004669

LR test vs. linear model: chi2(2) = 16.42 — Prob > chi2 = 0.0003

SENSITIVITY ANALYSIS: IMPACT OF SEASONAL DROUGHT CYCLE AND COVID-19 PANDEMIC ON STUDY OUTCOMES

Independent Variables

comunidad = community
id = household identification number
grupo_experimental = experimental group
escolaridad = maternal education
puntaje_pobreza =raw poverty score
inseguridad_base = food insecurity at baseline
sexo = sex of child
conteo_de_cultivos_base = crop out at baseline
diverisdad_ninos_base = child dietary diversity at baseline
gumshoes = number of children
escasez = season hunger
virtual = data collected during the COVID-19 pandemic

Dependent Variables

diversidad_minima_nino = minimum child dietary diversity
diversidad_minima_mujer = minimum dietary diversity in women
inseguridad = food insecurity
haz = length for age *z* score

Child Minimum Dietary Diversity

Mixed-effects logistic regression — Number of obs = 277

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	46.2	128
id	139	1	2.0	2

Integration method: mvaghermite — Integration pts. = 7

Wald chi2(10) = 23.80
Log likelihood = -127.43902 — Prob > chi2 = 0.0081

diversidad_minima_nino	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	3.15478	1.622012	2.23	0.025	1.151672	8.641905
grupo_experimental						
Experimental	.3122532	.1471024	-2.47	0.013	.1240241	.7861542
time#grupo_experimental						
1#Experimental	3.622627	2.662574	1.75	0.080	.8578353	15.29831
escolaridad	1.000006	.0559724	0.00	1.000	.8961055	1.115954
puntaje_pobreza	1.006901	.0173861	0.40	0.690	.9733952	1.04156
inseguridad_base	1.379223	.508482	0.87	0.383	.6696061	2.840857
sexo	1.045934	.3418244	0.14	0.891	.5512145	1.984667
edad	2.559475	.9429469	2.55	0.011	1.243243	5.269211
escasez	.827418	.2954397	-0.53	0.596	.4109538	1.665931
virtual	.6943045	.4550409	-0.56	0.578	.1921676	2.508532
_cons	1.70135	.8154023	1.11	0.268	.6650285	4.352584
comunidad						
var(_cons)	3.26e-41	7.25e-23			.	.
comunidad>id						
var(_cons)	.1411787	.715491			6.85e-06	2908.314

LR test vs. logistic model: chibar2(01) = 0.04 — Prob >= chibar2 = 0.4179

Minimum Dietary Diversity in Women

Mixed-effects logistic regression — Number of obs = 277

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	46.2	128
id	139	1	2.0	2

Integration method: mvaghermite — Integration pts. = 7

Wald chi2(10) = 12.99
Log likelihood = -169.11268 — Prob > chi2 = 0.2243

diversidad_minima_mujer	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	.7854956	.3002006	-0.63	0.528	.3713912	1.66133
grupo_experimental						
Experimental	.427932	.1808766	-2.01	0.045	.1868927	.9798445
time#grupo_experimental						
1#Experimental	2.420554	1.345755	1.59	0.112	.8140901	7.197094
escolaridad	1.087147	.0547772	1.66	0.097	.9849163	1.199988
puntaje_pobreza	1.015466	.0151096	1.03	0.302	.9862792	1.045516
inseguridad_base	1.802275	.5647413	1.88	0.060	.975209	3.330767
sexo	1.259408	.3520273	0.83	0.409	.728183	2.178175
edad	1.353828	.3890177	1.05	0.292	.7708565	2.377679
escasez	1.089687	.3374232	0.28	0.781	.5939177	1.999299
virtual	.8179711	.383088	-0.43	0.668	.3266531	2.048279
_cons	.8297793	.3549391	-0.44	0.663	.3588063	1.918956
comunidad						
var(_cons)	1.19e-30	6.30e-16			.	.
comunidad>id						
var(_cons)	.1600202	.4429428			.0007047	36.33598

LR test vs. logistic model: chibar2(01) = 0.15 — Prob >= chibar2 = 0.3497

Food Insecurity

Mixed-effects logistic regression Number of obs = 277

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	46.2	128
id	139	1	2.0	2

Integration method: mvaghermite Integration pts. = 7

Wald chi2(11) = 20.66
Log likelihood = -158.66924 Prob > chi2 = 0.0371

inseguridad	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	.6132741	.2890184	-1.04	0.300	.243505	1.544548
grupo_experimental						
Experimental	4.227899	2.453251	2.48	0.013	1.355852	13.18369
time#grupo_experimental						
1#Experimental	.4463433	.2951544	-1.22	0.223	.1221218	1.631342
escolaridad	1.025734	.0709665	0.37	0.713	.8956608	1.174698
puntaje_pobreza	.9478372	.0218236	-2.33	0.020	.9060144	.9915906
sexo	.9621229	.3944881	-0.09	0.925	.430747	2.149012
edad	3.213859	1.480568	2.53	0.011	1.302847	7.927941
diversidad_nino_base	.8517819	.3859472	-0.35	0.723	.3504646	2.070202
conteo_de_cultivos_base	1.092237	.0703682	1.37	0.171	.9626708	1.239243
escasez	1.616669	.6049458	1.28	0.199	.7764392	3.366158
virtual	1.298119	.8045878	0.42	0.674	.3852392	4.374196
_cons	.235171	.2052593	-1.66	0.097	.0425057	1.301128
comunidad						
var(_cons)	3.71e-32	4.79e-16			.	.
comunidad>id						
var(_cons)	2.044274	1.186193			.6555832	6.374559

LR test vs. logistic model: chibar2(01) = 7.64 Prob >= chibar2 = 0.0029

Length-for-Age *z* Score

Mixed-effects ML regression — Number of obs = 239

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	5	39.8	118
id	137	1	1.7	2

Wald chi2(10) = 28.81
Log likelihood = -198.48873 — Prob > chi2 = 0.0013

haz	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.2291802	.055468	-4.13	0.000	-.3378955	-.1204649
grupo_experimental						
Experimental	-.0843155	.1472936	-0.57	0.567	-.3730056	.2043746
time#grupo_experimental						
1#Experimental	.1715601	.0831711	2.06	0.039	.0085478	.3345724
escolaridad	.011309	.0202411	0.56	0.576	-.0283629	.0509808
puntaje_pobreza	.0041122	.0062491	0.66	0.511	-.0081359	.0163603
inseguridad_base	.1228936	.1285335	0.96	0.339	-.1290275	.3748146
diversidad_nino_base	-.1586582	.1327101	-1.20	0.232	-.4187652	.1014489
sexo	-.1154182	.1203363	-0.96	0.337	-.3512731	.1204367
edad	.15032	.1272839	1.18	0.238	-.0991519	.3997918
escasez	-.1284871	.0517437	-2.48	0.013	-.2299029	-.0270713
virtual	0	(omitted)				
_cons	-3.222607	.1811216	-17.79	0.000	-3.577599	-2.867615

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	9.58e-16	.	.	.
id: Identity				
var(_cons)	.4249523	.0585285	.3244177	.5566418
var(Residual)	.0854376	.0120304	.0648324	.1125915

LR test vs. linear model: chi2(2) = 114.23 — Prob > chi2 = 0.0000

Crop Count

Mixed-effects ML regression   Number of obs = 277

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	46.2	128
id	139	1	2.0	2

Log likelihood = -691.57376   Wald chi2(11) = 70.31
                                                               Prob > chi2 = 0.0000

conteo_de_cultivos_consum	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	-.2912666	.4067371	-0.72	0.474	-1.088457	.5059236
grupo_experimental						
Experimental	-1.671107	.8176812	-2.04	0.041	-3.273733	-.0684814
time#grupo_experimental						
1#Experimental	3.81012	.57473	6.63	0.000	2.68367	4.936571
escolaridad	.033874	.0797338	0.42	0.671	-.1224013	.1901493
puntaje_pobreza	-.0045615	.0239234	-0.19	0.849	-.0514505	.0423275
inseguridad_base	.1806993	.4896168	0.37	0.712	-.7789319	1.140331
diversidad_nino_base	-.4851384	.4985446	-0.97	0.330	-1.462268	.4919911
sexo	-.0876678	.4550458	-0.19	0.847	-.9795411	.8042056
edad	.3543848	.4832683	0.73	0.463	-.5928037	1.301573
escasez	1.125965	.3621336	3.11	0.002	.4161961	1.835734
virtual	-3.194802	.615917	-5.19	0.000	-4.401977	-1.987627
_cons	7.979316	.8587714	9.29	0.000	6.296155	9.662477

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	.2958333	.5905774	.0059126	14.80185
id: Identity				
var(_cons)	4.19692	.9265046	2.722832	6.469048
var(Residual)	5.294102	.6404841	4.176508	6.710753

LR test vs. linear model: chi2(2) = 31.26   Prob > chi2 = 0.0000

Nutritional Functional Diversity

Mixed-effects ML regression　　　　Number of obs = 271

Group Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
comunidad	6	10	45.2	128
id	136	1	2.0	2

Wald chi2(13) = 49.90
Log likelihood = 356.26579　　　　Prob > chi2 = 0.0000

diversidad_funcional_consum	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.time	.004007	.0100072	0.40	0.689	-.0156066	.0236207
grupo_experimental						
Experimental	-.0130972	.0221955	-0.59	0.555	-.0565997	.0304052
time#grupo_experimental						
1#Experimental	.0587447	.0144389	4.07	0.000	.030445	.0870443
sexo						
Masculino	-.0198969	.0129624	-1.53	0.125	-.0453027	.005509
sexo#grupo_experimental						
Masculino#Experimental	.035385	.0185308	1.91	0.056	-.0009347	.0717046
escolaridad	.0013624	.0016701	0.82	0.415	-.001911	.0046359
puntaje_pobreza	.0001751	.0005234	0.33	0.738	-.0008508	.0012009
inseguridad_base	.008437	.0098982	0.85	0.394	-.0109632	.0278372
diversidad_nino_base	-.0142299	.0099984	-1.42	0.155	-.0338264	.0053666
sexo	0	(omitted)				
edad	.004014	.009798	0.41	0.682	-.0151898	.0232177
num_hijos	-.0004975	.0023284	-0.21	0.831	-.0050611	.0040661
escasez	.0266206	.0089309	2.98	0.003	.0091163	.0441249
virtual	-.0684278	.0148129	-4.62	0.000	-.0974607	-.039395
_cons	.1688052	.0242951	6.95	0.000	.1211877	.2164228

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
comunidad: Identity				
var(_cons)	.0002374	.0003322	.0000153	.0036855
id: Identity				
var(_cons)	.0010456	.000393	.0005005	.0021843
var(Residual)	.0032174	.0003921	.0025337	.0040854

LR test vs. linear model: chi2(2) = 10.65　　　　Prob > chi2 = 0.0049