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Impact of gardening and nutrition support provided to women in refugee camps in Cox's Bazar, Bangladesh

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ABSTRACT

Nearly one million Rohingya refugees, displaced by the Myanmar civil war, live in densely populated camps in Cox's Bazar, Bangladesh. While food aid addresses some of their immediate needs, additional solutions are necessary to foster self-reliance, as many have been living in camps for years with little hope of returning home. Gardening is one approach that could enhance diets, food security, and incomes, but evidence for the impact of home garden programs in refugee camps remains limited. The objective of this study is to evaluate the impact of a home garden and nutrition program on the diets and food security of pregnant and lactating women in refugee camps in Cox's Bazar. A cluster-randomized controlled trial was conducted, with pre- and post-intervention data collected from 1050 women, evenly split into control and treatment groups. A difference-in-differences estimator was used to measure the intent-to-treat effects. Lack of space was the primary obstacle to gardening, but sack gardens and rooftop gardens offered solutions. Women reported many benefits from gardening beyond food consumption, such as personal joy and making the house look nice. The intervention led to a 17-percentage point increase in garden adoption ($p = 0.018$) and a 57-percentage point rise in households sourcing fruits and vegetables from their gardens ($p < 0.001$). It also improved nutrition knowledge by 23 percentage points ($p < 0.001$) and household food security by 66% ($p < 0.05$). The intervention led to a significant increase of 1 additional serving of fruit per week, but there was no significant increase in vegetable intake. These findings clearly show the benefits of providing gardening and nutrition training to nutritionally vulnerable women in densely populated refugee camps.

1. Introduction

The number of forcibly displaced people worldwide has nearly doubled over the past decade, reaching over 117.3 million by the end of 2023 (UNHCR, 2024). Displacement often lasts for years, with many people being displaced for a decade or longer. The Myanmar civil war, ongoing since 2021, has led to widespread displacement. Nearly 1 million people, mostly ethnic Rohingya, have fled to neighboring Bangladesh, where they live in Cox's Bazar's 33 refugee camps. The crisis has also affected the local community of more than 444,000 Bangladeshi residents in Cox's Bazar, a district vulnerable to natural hazards such as cyclones and flooding (HR, 2022).

While emergency food aid is essential for meeting the immediate food needs of a displaced population, livelihood support is key for long-term stability. There is a growing focus on strengthening the livelihoods of displaced individuals and host communities by helping them grow and sell food crops, which simultaneously provides income and meets their food needs (Gichunge and Kidwaro, 2014; Millican et al., 2019; Nisbet et al., 2022). Vegetables are usually the focus of such programs because they can be grown on small plots, generate income quickly, and help address micronutrient deficiencies (Keats and Wiggins, 2013; Weinberger and Lumpkin, 2007).

Previous impact studies of home garden interventions targeting women in rural areas of Africa and Asia have generally shown positive

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effects on household vegetable production and consumption (e.g., Depenbusch et al., 2022 for Cambodia; Murty et al., 2016 for India; Rosenberg et al., 2018 for Zambia), diet quality (e.g., Blakstad et al., 2021 for Tanzania), and food security (e.g., Tesfamariam et al., 2018 for South Africa; Ogutu et al., 2023 for India). Two systematic reviews confirmed positive effects on dietary diversity, but concluded that there is only limited evidence for effects on anthropometric outcomes and long-term nutrition (Ruel et al., 2018; Webb and Kennedy, 2014). The evidence for the impact of home garden interventions is particularly strong for Bangladesh, where previous studies showed significant effects on vegetable production and crop diversity (e.g., Baliki et al., 2019; Kehlenbeck et al., 2026; Schreinemachers et al., 2016), vegetable consumption and dietary diversity (e.g., Ahmed et al., 2024; Kang et al., 2023; Schreinemachers et al., 2025), and women's empowerment (Baliki et al., 2022; Kawarazuka et al., 2023; Waid et al., 2022).

Nearly all previous studies of home garden interventions have studied their impact on women in rural farm households. There is still limited evidence supporting the promotion of vegetable gardening in refugee camps or in crisis settings more generally. Baliki et al., (2023) summarized the evidence on home garden interventions in crisis settings through a review of the literature and a survey of 69 home garden programs. While 29 of the 69 programs were implemented in refugee camps, they found no academic papers evaluating the impact of home gardens in such settings. They called for increased collaboration between researchers and implementers to generate evidence that enhances the effectiveness of home gardening programs in emergency contexts.

As an example of one such collaboration, Tran et al., (2025) studied the impact of a World Vision-implemented home garden and nutrition program in Cox's Bazar on dietary diversity and food security. However, the study focused on the host population rather than the refugee population. Based on a sample of 600 participating households interviewed after the program, the study found that own food production was positively associated with food security and had a positive, though only marginally significant, effect on dietary diversity (Tran et al., 2025). Refugee households face distinct constraints, such as limited access to land and restricted mobility, as they cannot leave the camp. Such constraints can affect the success and sustainability of gardening interventions (Poulsen et al., 2015).

Therefore, this study aims to fill this evidence gap by testing the hypothesis that supporting home gardening among displaced people (refugees), specifically pregnant and lactating women with malnourished children, improves their ability to produce food, contributing to better diet quality and food security. The case of Rohingya refugees in Bangladesh is used to test this hypothesis. The study's findings help to broaden the evidence base beyond rural farm households and can help guide the inclusion of vegetable gardening in future support programs.

Our study shows that the intervention increased the adoption of household gardens and the share of households sourcing their fruits and vegetables from them. While we did not find significant changes in vegetable consumption, fruit intake increased, household food security improved, and respondents gained more knowledge about food and nutrition.

2. Methods and data

2.1. Intervention studied

The intervention was part of the project "Comprehensive, Integrated Multi-Sector Response for Rohingya Refugees and Host Communities in Cox's Bazar (BPRM)," led by the International Rescue Committee (IRC) and carried out by Concern Worldwide and the Society for Health Extension and Development (SHED) in Rohingya Camps from September 2023 to August 2026.

The project targeted households with pregnant and lactating women (PLW), using the following eligibility criteria: households with a severe acute malnourished (SAM) or moderate acute malnourished (MAM) child under the age of five years, PLW living with a disability or living with a disabled person in the household, women with an infant enrolled in the IYCF-MAMI program,[1] or PLW who is a widow or who is a family head. The project aimed to reach approximately 50,000 women over a three-year period.

There are three main cropping seasons in Bangladesh: the *rabi* season (mid-October to mid-March), the summer or *Kharif* 1 (mid-March to mid-July), and the monsoon or *Kharif* 2 (mid-July to mid-October). Participants received agricultural support twice within a 12-month period (Fig. 1). In the summer season, inputs and training were provided from mid-June to mid-July 2024. In the winter season, training was provided in mid-November 2024, and inputs were provided at the end of December 2024.

The intervention included three components as described below.

Component 1. Promotion of optimal maternal, infant and young child nutrition practices using the support group approach: Trained community nutrition volunteers and mobilizers supervised 10–12 mother support groups at each of the three camps included in the study (approximately once per month for 12 months). Each group included pregnant and lactating women and had one lead mother responsible for training others on 12 different health, nutrition, and hygiene topics. After completing the training, the groups graduated, and the lead mother trained the next group of women. Men were involved in mother, infant, and young child activities to promote a shared understanding of key behaviors between spouses.

Component 2. Awareness campaigns: Alongside Support Group activities, awareness campaigns were conducted to encourage effective behavior change and health-seeking actions. These included engaging influential community members to deliver messages, organizing community events (e.g., World Breastfeeding Week, Nutrition Action Week), and supporting national government nutrition programs such as Vitamin-A Plus campaigns.

Component 3. Support to grow seasonal vegetables and fruits to improve dietary diversity: Comprehensive training on small-scale climate-smart agriculture was provided, such as home vegetable gardening, organic composting, vermicomposting, seed preservation, nutrient content of vegetables, pest and disease management, soil preparation, irrigation methods using household wastewater, and crop species and variety selection. The project established demonstration/model gardens to showcase organic and climate-resilient gardening methods. Context-specific and innovative models were promoted, including backyard and sack gardens, boxes/containers, perma-gardens, and layered and vertical garden options. Vegetable seeds, organic fertilizer, and gardening tools were provided. Seeds included 5 g each of sweet gourd, bitter gourd, bottle gourd, ash gourd, and cucumber, 50 g each of red amaranth, Indian spinach, and yardlong bean, and 50 mg of kangkong (water spinach), and eggplant.

2.2. Evaluation design

The study was designed as a cluster-randomized controlled trial. Optimal Design Plus (ODP) was used to estimate the required sample size by calculating the Minimum Detectable Effect (MDE) for measuring outcomes, with 80% power. We assumed a clustered design and estimated that 50 clusters of 10 households each would be sufficient to detect a small-to-medium effect size (0.30) on the adoption of home gardens. Assuming a 5% sample attrition between baseline and endline, we targeted a sample of 1050 households (12 households per cluster), evenly split between treatment and control.

Three camps where the intervention had not yet been implemented were selected for the study. Assigning one entire camp as a control group was not feasible because the implementing partner was obligated to

[1] IYCF=infant and young child feeding; MAMI=management of small and nutritionally at-risk infants and their mothers.

Fig. 1. Timeline of agricultural seasons and intervention in 2024–2025.

provide services in all camps. Refugee camps in Cox's Bazar are divided into blocks and subblocks. The three selected camps had 19 blocks, 185 subblocks, and a population of about 2,930 eligible women. Of these, approximately 2000 were targeted for the intervention in 2024, with the rest expected to receive support in the following year.

Clustering was used to prevent spillover effects between treatment and control groups, although spillover effects cannot be completely avoided in a camp setting. Clusters were defined at the block level in order to reduce potential spillover effects between treatment and control groups. Random assignment of blocks to treatment and control groups was not possible because blocks varied substantially in size (ranging from 14 to 450 eligible women) and because the program required reaching approximately 2000 women. It was therefore necessary to assign blocks with larger eligible populations to the treatment group and smaller blocks to the control group.

From each block, we randomly selected five subblocks for inclusion in the study. The selection was proportional to size, so subblocks with more eligible women had a higher chance of being selected, thus avoiding the inclusion of many small subblocks. The design did not impose a minimum distance between control and treatment subblocks,

Fig. 2. CONSORT flow diagram of the trial.

but program implementers confirmed that these were usually 250–500 m apart. Women were randomly selected from the selected subblocks based on the sample targets per block. The final sample of 1072 women at baseline is representative of the entire population of pregnant and lactating women across the three camps. Sample attrition at the endline was only 2.1%. Consequently, the analytical sample consisted of 1050 women, evenly split between treatment and control groups. The flow of the experiment is summarized in Fig. 2 as a CONSORT diagram. While the study largely complies with CONSORT guidelines, these were not strictly followed.

2.3. Data collection

A team of 20 experienced enumerators collected the baseline data in March 2024 and the endline data in February 2025. Collecting data during the same season reduces variability due to seasonal changes, which could impact garden production and food consumption. The baseline data collection partially overlapped with the Islamic holy month of Ramadan. During this period, people fast from dawn to dusk. While pregnant and lactating women are not obligated to fast, most of them do. It was not possible to delay the survey until after Ramadan, as doing so would delay the intervention. It also could not be conducted before Ramadan, as time was needed to compile the list of eligible women and prepare and test the survey tools. The questionnaire modules affected by fasting were related to food consumption: the 24-hour food recall and average fruit and vegetable intake recall. Unfortunately, more households in the treatment group were interviewed before fasting began, while more households in the control group were interviewed during fasting, which could bias the results. Therefore, we decided not to use these modules from the baseline in the analysis.

The endline survey documented participants' involvement and satisfaction with the intervention. Among the 525 women in the treatment group, 463 (88%) confirmed they received both the mother support group (MSG) component and home gardening training and inputs. Of the 62 women who did not receive full support, 14 received only the MSG component, 14 received only home garden support, and 34 (6%) received no support at all. Of the 477 women who received MSG support, 33% reported being satisfied, and 66% were very satisfied. Of the 477 women who received home garden support, 29% were satisfied, while 71% were very satisfied.

2.4. Outcome variables

Table 1 summarizes the outcomes tested in this study. Primary outcomes include garden adoption and vegetable consumption, along with household food insecurity measured using the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007). Secondary outcomes encompass intermediate factors, such as the area used for home gardens and the number of gardening practices applied, which help to understand the adoption of learned practices. It also includes outcomes likely resulting from the intervention but not the main focus, such as social cohesion and self-esteem.

2.5. Empirical strategy

Data were collected before the start of the intervention (baseline) and one year later (endline). The study measured the average treatment effect (intent-to-treat), which is the difference in mean outcomes between units assigned to the treatment and units assigned to the control, using a difference-in-differences (DID) approach specified as:

$$\text{Outcome}=\alpha+\beta\ (\text{Treatment})+\gamma\ (\text{Period})+\delta\ (\text{Treatment}\times\text{Period})+\varepsilon_i \quad (1)$$

where Treatment is a dummy variable separating the treatment group from the control group, and Period is a dummy variable separating baseline from endline data. Parameter δ represents the average

Table 1
Primary and secondary outcomes used in the study.

Outcome	Unit	Description
Primary outcomes:		
Garden adoption	0/1	The adoption of gardening by a household is measured as yes/no.
Vegetable consumption	Servings per week	The module refers to regular meals eaten during the 4 weeks prior to the survey. Respondents were asked 1) “How many days a week do you usually eat vegetables? 2) On a day you eat vegetables, how many meals usually include vegetables? And 3) For a meal that includes vegetables, how many serving spoons do you usually eat? The three variables are then multiplied to get the average number of portions of vegetables/week. The method uses a local serving spoon and photos of portion sizes of different cooked vegetable dishes.
Household Food Insecurity Access Scale (HFIAS)	0–27	Nine questions about a household's experience of food insecurity in the preceding month, each scored 0 to 3, with the sum ranging from 0 to 27 (Coates et al., 2007).
Secondary outcomes:		
Area under vegetables	m^2	Area of land allocated to vegetable production, including boxes and containers, measured by enumerators with measuring tape.
Seasonal harvesting from the home garden	%	Share of households harvesting from the home gardens in each season.
Garden practices	0–15	The number of garden practices adopted out of 15, such as using a nursery, raised planting beds, fences, animal manure, harvesting rainwater, making compost, rotating crops, using mineral/chemical fertilizer, natural pesticides, insect nets, seedling trays, mulching, seed saving, vermicompost, and using geo-bags.
Knowledge of food and nutrition	percentage	Food and nutrition knowledge of respondents was tested using 12 true or false statements and expressed as the percentage of correct answers.
Fruit consumption	Servings per week	The module refers to regular meals eaten during the 4 weeks prior to the survey. Respondents were asked 1) “How many days a week do you usually eat fruits? 2) On a day you eat fruits, how many portions do you usually eat? The variables are then multiplied to get the average number of portions of fruits/week.
Minimum dietary diversity for women (MDD-W)	0/1	Calculated from the Diet Quality Questionnaire (DDQ) (Global Diet Quality Project, 2022). It is a binary measure that indicates if a woman has consumed five out of ten food groups 24 h before the survey.
Diet Diversity Score (DDS)	0–10	Calculated from the DDQ. Represents the number of food groups (out of 10) consumed in the 24 h prior to the survey.
Self-esteem	0–30	Rosenberg's Self-Esteem Scale is the standard measure of self-esteem in psychological research. It includes ten questions and creates a score from 0 to 30 (M. Rosenberg, 1965). This has been validated in Bangladesh (Akhter & Ferdous, 2019) but not in the Rohingya context.
Social cohesion	0–15	A subset of Keyes' Social Well-being questionnaire focusing on social integration and social contribution, each with six questions in total, and

(continued on next page)

Table 1 (*continued*)

Outcome	Unit	Description
		scored 0 to 15 (Keyes, 1998). This has been validated in Bangladesh (Hasan et al., 2023) but not in the Rohingya context.

treatment effect. The model is estimated using ordinary least squares regression with robust standard errors. The covariates of respondents' age, formal education, and whether they maintained a home vegetable garden before displacement were chosen a priori and added to control for any structural differences between the treatment and control groups at baseline. The method assumes that the intervention and control groups are equally exposed to external influences that could affect outcomes (e.g., weather, market prices, etc.) other than the intervention itself.

To analyze the outcome variables related to food consumption, we only used the endline data (as mentioned in Section 2.3). We did this using propensity score matching (PSM). The analysis begins by regressing treatment assignment on a set of characteristics that influence both treatment status and outcomes. Covariates, defined a priori, included respondents' age, formal education, and whether they maintained a home vegetable garden before being displaced. PSM ranks households by their conditional probability of receiving the treatment (Rosenbaum and Rubin, 1983). Using the nearest-neighbor algorithm, each treated household was matched with the most similar non-treated household, and vice versa. Outcomes are compared across these matched pairs, and the differences are averaged to estimate the average treatment effect.

2.6. Ethics approval

The study was reviewed and approved by the World Vegetable Center's Institutional Biosafety and Research Ethics Committee (IBREC Reg. No. 2024-006) before the start of the data collection. Approval to enter the camp was given by the Office of the Refugee Relief and Repatriation Commissioner. Informed consent was obtained verbally by the enumerators, considering that most respondents were illiterate, and recorded on tablet computers used to collect all survey data.

3. Results

3.1. Sample characteristics

Respondents in control and treatment groups were broadly similar at baseline in terms of age (about 28 years), household size (approximately 6 members), and most other demographic indicators (Table 2). However, there were a few small but statistically significant differences: treatment households had slightly more young children under 5 years of age (1.68 vs. 1.59, $p = 0.051$), fewer elderly members (0.08 vs. 0.12, $p = 0.044$), and had been in the camp a bit longer (6.73 vs. 6.68 years, $p = 0.017$). A higher proportion of treatment households reported having had a vegetable garden in their home prior to becoming refugees (100% vs. 94%, $p = 0.009$). They also lived somewhat farther from the nearest market (25 vs. 23 min, $p = 0.007$).

3.2. Constraints to gardening in a refugee camp

At endline, both treatment and control gardeners identified lack of space as the most common constraint, with a higher percentage in the treatment group (77% vs. 68%) (Fig. 3). Many gardeners in the control group mentioned other constraints, such as limited access to good seeds, problems with insect pests, expensive inputs, and damage from rodents; however, these issues were much less frequently mentioned in the treatment group, suggesting that the intervention was effective in overcoming many of these constraints.

Table 2
Key characteristics of the sample at baseline, means with standard deviations in parentheses.

Characteristic	Control (n = 525)	Treatment (n = 525)	Difference in means	p-value[1]
Respondent age (years)	28.23 (5.93)	28.02 (6.09)	0.21	0.560
Household size (persons)	5.86 (1.80)	5.90 (2.03)	−0.04	0.748
Household members by age category (persons):				
–Under 5 years old	1.59 (0.70)	1.68 (0.73)	−0.09	0.051
–5 to 16 years old	1.81 (1.55)	1.80 (1.64)	0.01	0.877
–17–60 years old	2.39 (1.04)	2.33 (1.15)	0.05	0.431
–Over 60 years old	0.12 (0.36)	0.08 (0.31)	0.04	0.044
No schooling (proportion)	0.37 (0.48)	0.33 (0.47)	0.04	0.196
Years in camp	6.68 (0.19)	6.73 (0.42)	−0.05	0.017
Farmed in the original home (proportion)	0.93 (0.38)	0.95 (0.34)	−0.02	0.263
Vegetable garden in original home (proportion)	0.94 (0.35)	1.00 (0.38)	−0.06	0.009
Distance to the nearest market (minutes)	23.23 (10.16)	25.03 (11.37)	−1.80	0.007

Notes: [1] Student's *t*-test.

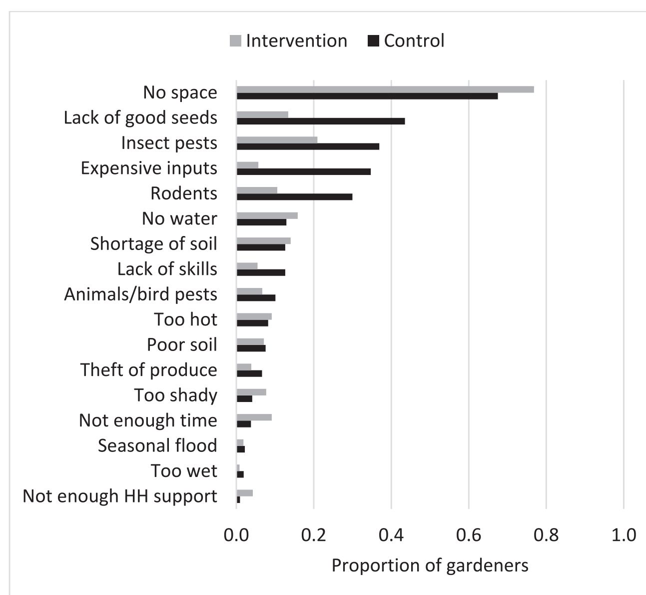

Fig. 3. Constraints to gardening at endline, by control and treatment. Note: subsample of households involved in gardening. Not enough HH support refers to "Not enough support from other household members.

3.3. Perceived benefits of gardening

Gardeners in the control and treatment groups were asked about the benefits they receive from gardening and how strongly they feel about these benefits (categorized as "a lot", "a little", or "none"). Responses, as shown in Fig. 4, were similar between control and treatment. Respondents associated gardening most strongly with personal enjoyment (81% reporting "a lot") and with improving the appearance of their

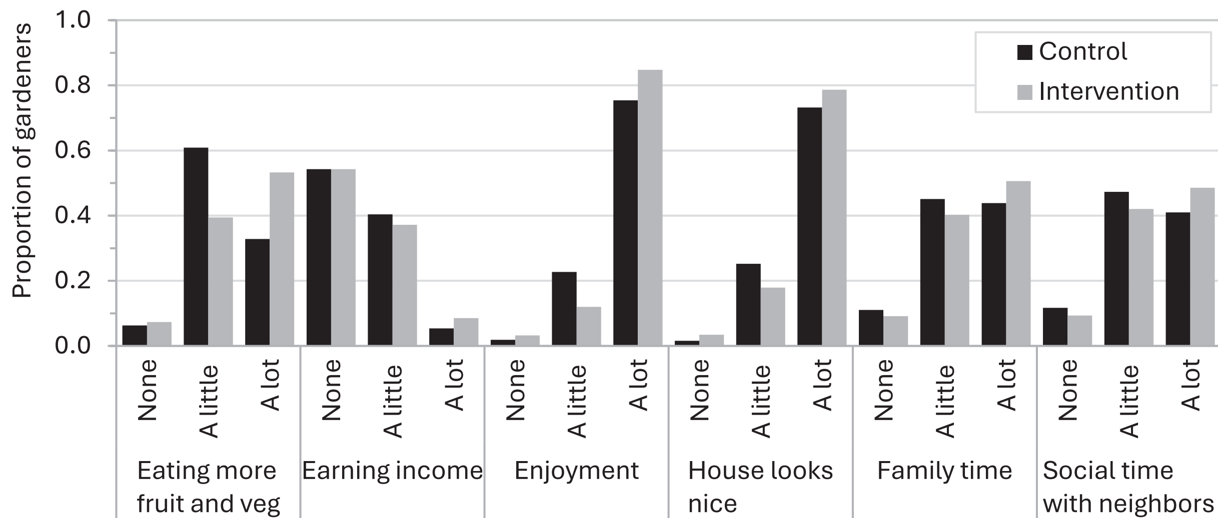

Fig. 4. Perceived benefits of gardening at endline.

house (77%). Eating more fruits and vegetables (45% "a lot," 48% "a little"), spending more time with family (48% "a lot," 42% "a little"), and socializing with neighbors (46% "a lot," 44% "a little") were also commonly noted. In contrast, earning income was rarely seen as a major benefit of gardening (only 7% "a lot," 38% "a little").

3.4. Garden adoption and practices

The intervention had a positive effect on the adoption of home gardens, with the average treatment effect being 17 percentage points ($p = 0.018$) (Table 3). Of the women in the treatment group, 94% reported doing gardening at the endline. In-ground gardens were the most common type of garden at the baseline (24%), but at the endline, sack gardens were the most common (54%), a large increase from 16% at the baseline. The treatment effect on sack garden adoption was 21 percentage points ($p = 0.002$), and that of rooftop garden adoption was 27 percentage points ($p = 0.044$).

The average treatment effect on the number of seasons (maximum three in Bangladesh) in which a household produced crops was 0.722 ($p < 0.001$). Participants were asked how many of the 15 gardening practices covered in the training they used. The most common practices include using chemical fertilizers, insect nets, and raised seed beds, but the treatment effects were not significant for any of these practices. All other practices were reported by 10 percent or less of the respondents and are not shown in the table. There was no significant effect on the total number of practices applied. Sources of fruits and vegetables were similar between treatment and control groups at baseline, with purchase being the primary source, followed by food aid and home production

Table 3
Impact on the adoption of home gardens and gardening practices.

Outcome	Baseline (n = 525)			Endline (n = 525)			Impact	
	Control	Treatm.	p-value[1]	Control	Treatm.	p-value[1]	ATE	p-value
Has garden (1 = yes)	0.41(0.49)	0.58(0.49)	<0.001	0.60(0.49)	0.94(0.24)	<0.001	0.17(0.06)	0.018
Garden type (proportion):								
–In-ground	0.20 (0.40)	0.28 (0.45)	0.003	0.23 (0.42)	0.31 (0.46)	0.003	0.01 (0.04)	0.858
–Sack	0.14 (0.35)	0.18 (0.38)	0.107	0.41 (0.49)	0.66 (0.47)	<0.001	0.21 (0.06)	0.002
–Keyhole	0.07 (0.25)	0.14 (0.34)	<0.001	0.09 (0.29)	0.25 (0.43)	<0.001	0.09 (0.04)	0.073
–Roof	0.00 (0.00)	0.01 (0.07)	0.083	0.01 (0.07)	0.04 (0.19)	<0.001	0.27 (0.01)	0.044
–Tire pot	0.00 (0.00)	0.01 (0.10)	0.025	0.01 (0.07)	0.02 (0.15)	0.012	0.01 (0.01)	0.370
# of seasons producing (0–3)	0.78 (1.15)	0.99 (1.2)	0.003	1.37 (1.28)	2.29 (0.94)	<0.001	0.72 (0.16)	<0.001
Garden area (sqm)	0.96 (3.49)	1.83 (4.86)	<0.001	2.24 (7.36)	3.92 (8.17)	<0.001	0.81 (0.93)	0.395
# of garden practices (0–15)	0.75 (1.09)	0.85 (1.19)	0.131	0.75 (1.01)	1.14 (1.21)	<0.001	0.29(0.25)	0.254
Chemical pesticides (adverse effect)	0.20 (0.40)	0.28 (0.45)	0.003	0.30 (0.45)	0.30 (0.45)	0.946	−0.08 (0.07)	0.250
Key practices and inputs:								
–Insect nets	0.10 (0.30)	0.13 (0.33)	0.172	0.20 (0.40)	0.30 (0.45)	<0.001	0.07 (0.05)	0.224
–Chemical fertilizers	0.18 (0.39)	0.18 (0.38)	0.936	0.17 (0.38)	0.17 (0.37)	0.806	−0.01 (0.08)	0.951
–Raised beds	0.13 (0.34)	0.18 (0.38)	0.027	0.13 (0.33)	0.17 (0.38)	0.056	−0.01 (0.09)	0.947

Notes: [1] Student's *t*-test. ATE = average treatment effects estimated using DID. DID regressions include controls for respondent age, formal education, and vegetable gardening in the original home.

Table 4
Impact on sources of fruit and vegetables for household consumption and knowledge of food and nutrition.

Outcome	Baseline (n = 525)			Endline (n = 525)			Impact	
	Control	Treatm.	p-value[1]	Control	Treatm.	p-value[1]	ATE	p-value
Sources of fruit and vegetables (proportion of households):								
–Food aid	0.56 (0.50)	0.53 (0.50)	0.322	0.28 (0.45)	0.47 (0.50)	<0.001	0.21 (0.11)	0.073
–Purchase	0.99 (0.07)	1.00 (0.04)	0.317	0.97 (0.18)	0.97 (0.17)	0.860	−0.00 (0.10)	0.927
–Home garden	0.33 (0.47)	0.39 (0.49)	0.047	0.31 (0.46)	0.94 (0.24)	<0.001	0.57 (0.07)	<0.001
–Gifts	0.00 (0.00)	0.01 (0.11)	0.008	0.16 (0.37)	0.21 (0.41)	0.047	0.03 (0.07)	0.674
Knowledge of food and nutrition (0–12)	7.16 (1.51)	7.16 (1.75)	0.970	8.08 (2.42)	10.85 (1.31)	<0.001	2.78 (0.33)	<0.001

Notes: [1] Student's *t*-test. ATE = average treatment effects estimated using DID. DID regressions include controls for respondent age, formal education, and vegetable gardening in the original home.

(Table 4). However, the endline showed a sizable and significant increase in the share of treatment households obtaining fruit and vegetables from their gardens (from 39% to 94%), resulting in a large average treatment effect of 57 percentage points ($p < 0.001$). There was no significant change in the proportion of households purchasing fruits and vegetables, suggesting that home production did not necessarily replace market purchases.

Respondents were tested on their basic knowledge of food and nutrition. The intervention had a strong and statistically significant effect on this. While the mean baseline scores were the same for the control and treatment groups (mean score of 7.16), scores increased more in the treatment group than in the control, indicating a treatment effect of +39% ($p < 0.001$).

3.5. Fruit and vegetable consumption

The results show no significant effect on vegetable consumption of the respondent, measured as the average number of servings per week ($p = 0.162$) (Table 5). However, the effect on fruit consumption was positive and significant, with an average of 1.02 additional servings per week ($p = 0.020$). There was no significant effect on the diet diversity score (DDS), nor on the proportion of women achieving minimum dietary diversity ($p = 0.127$). Spending on fruit and vegetables was not affected by the intervention ($p = 0.191$). These results suggest that while the intervention may have supported increased fruit intake, it did not lead to broader improvements in dietary diversity.

3.6. Food security and other benefits

The intervention significantly reduced household food insecurity, as shown in Table 6. At baseline, intervention households had a noticeably higher HFIAS than control households (4.50 vs. 3.12, $p < 0.001$), indicating greater food insecurity. However, by the endline, HFIAS scores had decreased in the treatment group, dropping to 2.63 compared with 3.78 in the control group ($p < 0.001$). The treatment effect was − 2.50 ($p = 0.019$), representing a 66% reduction in food insecurity.

Table 5
Impact on dietary outcomes.

Outcome	ATE	SE	p-value	PO mean
Vegetable consumption (servings/week)	1.94	1.39	0.162	51.88
Fruit consumption (servings/week)	1.02	0.44	0.020	7.84
MDD-W (0/1)	−0.05	0.03	0.127	0.63
Diet Diversity Score (0–10)	−0.15	0.09	0.090	4.98
Spending on fruit and vegetables (USD/week)	−0.14	0.10	0.191	4.44

Notes: N = 1050. ATE = Average treatment effect. SE = standard error. PO mean=Potential outcome mean. Propensity scores include controls for respondent age, formal education, and vegetable gardening in the original home.

The intervention had mixed effects on women's mental and social health (Table 6). There was a positive but not statistically significant impact on women's self-esteem, as both the control and treatment groups showed slight improvements on the self-esteem scale. Even when focusing solely on gardening-related aspects of self-esteem, both groups demonstrated similar progress. The measure of social integration revealed no significant effect, though both groups reported high and fairly consistent levels of social integration. The average score for social contribution rose slightly in the intervention group while decreasing in the control group, but the treatment effect remained insignificant.

4. Discussion

4.1. Reflection on key findings

The home garden and nutrition intervention targeting pregnant and lactating women in refugee camps in Cox's Bazar led to a substantial increase in home garden adoption. The share of households with an active garden rose by nearly 17 percentage points, and participants cultivated across three seasons, indicating that households were able to produce food more consistently throughout the year. These effects are notable given the extreme land scarcity in camps. Many of the gardens were sack gardens and rooftop gardens, which demonstrates that training and inputs can overcome space constraints. Consistent with other studies in resource-constrained settings, like cities (e.g., Alemu et al., 2019; Schreinemachers et al., 2025), this shows that small-scale home gardening is both feasible and scalable when technical and material support are provided.

These results are quite specific to a particular population group—pregnant and lactating women with a malnourished child—and to the local context of refugee camps in Cox's Bazar. While it may not be possible to generalize these findings to other settings in Asia and Africa, they still help confirm that home gardening in resource-limited environments can lead to positive outcomes. As such, the results reinforce existing evidence on the impact of home garden interventions, especially in Bangladesh. Nearly all previous studies were conducted on women in rural households. Therefore, the main contribution of this work is the application of home gardens in a novel setting marked by severe resource and mobility constraints for women. Still, more research on home gardening and nutritional support for women in refugee camps is needed to strengthen the evidence base.

Households in the treatment group were more likely to source fruits and vegetables from their own gardens while still buying them from markets. This suggests that gardening complemented, rather than replaced, market purchases. This is understandable because the gardens are too small to provide enough produce. As a result, selling garden produce was minimal, highlighting an important point: garden training does not offer a significant income source in refugee camps. Another explanation for the lack of selling is that women prioritized household

Table 6
Impact of the intervention on household food insecurity and social indicators.

Outcome	Baseline (n = 525)			Endline (n = 525)			Impact	
	Control	Treatm.	p-value[1]	Control	Treatm.	p-value[1]	ATE	p-value
HFIAS score	3.12 (3.14)	4.50 (3.51)	<0.001	3.78 (4.05)	2.63 (2.99)	<0.001	−2.50 (0.96)	0.019
Self-esteem scale	15.01 (1.42)	14.83 (1.45)	0.038	15.25 (1.60)	15.52 (1.56)	0.004	0.46(0.27)	0.107
Social integration (0–15)	10.41 (1.00)	10.72 (1.14)	<0.001	10.22 (0.87)	10.46 (1.09)	<0.001	−0.05 (0.18)	0.779
Social contribution (0-15)	8.20 (1.90)	8.04 (1.91)	0.174	7.99 (0.98)	8.12 (1.43)	0.084	0.29 (0.39)	0.471

Note: [1] Student's *t*-test. ATE = Average treatment effect.

food consumption over selling because the importance of fruit and vegetable consumption had been emphasized in the training. The substantial improvement in women's food and nutrition knowledge, observed in the study, supports this explanation.

These positive effects stand in contrast to the lack of significant improvements in vegetable consumption and women's dietary diversity. There could be several reasons for this. First, the measurement of dietary diversity relied on a single 24-hour recall, whereas most other outcomes used recall periods of a month, a season, or a year. A single-day recall may not capture seasonal consumption of own-produced foods. Second, we only had endline data available for this measurement, so we had to rely on a PSM estimator, which is inferior to the DID estimator. Third, the dietary intake data refer only to women, and it is possible that women supplied additional produce to other household members, as is customary in Rohingya culture. It may be that children's vegetable consumption in treatment households increased. While the intervention targeted mothers, future work should collect food consumption data from multiple members. Our findings are, however, in agreement with several other nutrition-sensitive agriculture programs, where production gains did not automatically improve diets without concurrent changes in food environments, gender dynamics, and income use (Masset et al., 2012; Ruel et al., 2018; Ruel and Alderman, 2013; Sibhatu and Qaim, 2018). Evidence from these studies indicates that agricultural production can only lead to improved nutrition if addressing issues such as food preferences, market access, and intra-household food allocation.

The reduction in household food insecurity was surprisingly strong, with an average treatment effect of −66%. It aligns with evidence from other studies showing that even modest home gardens can enhance food security in resource-limited settings (Baliki et al., 2022; Tran et al., 2025). A study assessing the impact of home garden training in urban Dhaka, facing similar space constraints for setting up gardens, also found a 23% decrease in food insecurity (Schreinemachers et al. 2025).

While participants clearly linked gardening to benefits, such as personal enjoyment, home aesthetics, and community involvement, these effects were not statistically significant when using scientific outcome measures of mental well-being, social cohesion, and social integration. However, the time between baseline and endline was only one year, which is likely too short to detect changes in such outcomes.

4.2. Study strengths and weaknesses

The assessment of dietary outcomes relied solely on endline data. DDS and MDD-W were calculated from a 24-hour recall. Fruit and vegetable intake was calculated from the respondent's average weekly intake over the previous month prior to the survey. Such short-term recalls provide a snapshot of dietary behavior, which may not reflect women's usual diet. Collecting dietary data multiple times would be ideal, but it would significantly increase data collection costs. The one-year interval between baseline and endline is also relatively short, and conducting repeated surveys over a longer period could strengthen the study.

A major challenge of conducting a trial in refugee camps is that many organizations are active there, providing various types of support, including gardening assistance. As a result, finding a suitable counterfactual is difficult. Camp authorities coordinate the work of aid organizations to ensure that all refugees get the same level of support. Still, we cannot entirely rule out that some households in the control group received nutrition or gardening support during the study period. Also, given the densely populated setting, some spillover effects from the treatment to the control group are possible, although these are likely to be small within a one-year period.

Key strengths of the study include that it is likely the first randomized controlled trial of a home garden and nutrition intervention within a refugee camp, providing unique and valuable evidence for the effects of such programs. Another strength is that it assessed a wide range of outcomes from garden adoption and production practices to diets and food security, offering evidence for each stage of the program's impact pathway.

5. Conclusion

Home garden and nutrition support provided to nutritionally vulnerable women in refugee camps in Cox's Bazar, Bangladesh, significantly increased garden adoption, the number of months gardens were productive, and the use of garden produce for household consumption. There was a positive and significant effect on fruit intake, but no significant effect on vegetable intake. However, a significant improvement in household food security was observed. Women reported multiple benefits from gardening. The combination of garden training and nutrition education appears effective as women were motivated to use the garden to improve the quality of the household diet. The lack of space was the main constraint gardeners faced.

These results demonstrate that home gardens are viable in the context of a densely populated refugee camp and that households can grow food under very challenging conditions. The findings expand the evidence base for home garden interventions, which has mostly been based on women's home gardens in rural areas. Refugees have very few resources at their disposal, and sustaining garden production may require regular support, including the provision of seeds, fertilizers, and other inputs.

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CRediT authorship contribution statement

Liz Ignowski: Writing – original draft, Formal analysis. **Pepijn Schreinemachers:** Writing – original draft, Conceptualization. **Md**

Maniruzzaman: Writing – review & editing, Data curation. **Regine Kopplow:** Writing – review & editing, Conceptualization. **Nasir Md. Uddin:** Investigation, Writing – review & editing. **Mercy Mwambi:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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