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Baliki, Ghassan; Al Daccache, Melodie; Ghattas, Hala; Brück, Tilman

## Article — Published Version Short- and medium-term impacts of small-scale vegetable support on food security: evidence from Syria

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#### **ORIGINAL PAPER**



# Short- and medium-term impacts of small-scale vegetable support on food security: evidence from Syria

Ghassan Baliki<sup>1,5</sup> · Melodie Al Daccache<sup>1,2,5</sup> · Hala Ghattas<sup>2,3</sup> · Tilman Brück<sup>1,4,5</sup>

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#### Abstract

Small-scale agricultural and horticultural interventions play a critical role in improving nutrition and food security of vulnerable households in peaceful settings. However, scant rigorous evidence exists on the impacts and sustainability of such interventions in conflict settings. In this paper, we address this knowledge gap by analyzing the short- and medium-term impacts of a small-scale vegetable input support program involving asset transfers on food security and diets in war-time Syria. We use longitudinal panel household survey data from a quasi-experimental study collected at three rounds: before, one year, and two years after the horticultural intervention ended. We use propensity score matching and fixed-effect regression models to estimate the average treatment effects on the treated. We find that the vegetable support significantly improves food security by 21% and 19% in the short- and medium-term, respectively. More specifically, we find that the intervention significantly increased the consumption of nutrient-rich food groups such as vegetables, root tubers, fruits, eggs, pulses and nuts, milk, and oil and fats. Moreover, we find that the intervention reduces in the short-term the use of harmful coping strategies by 17%. However, this effect dissipates two years after the end of the intervention. The findings underscore the importance of small-scale vegetable support in addressing food insecurity in protracted conflict settings.

Keywords Agricultural interventions · Vegetables · Food security · Nutrition-sensitive · Syria · Conflict

#### 1 Introduction

In conflict-affected settings, common humanitarian responses to alleviate food insecurity involve assistance in the form of cash transfers, vouchers, and in-kind food assistance (Brück et al., 2019a). Emerging evidence has been documented for the impact of these interventions on

Ghassan Baliki baliki@isdc.org; ghassan.baliki@hu-berlin.de

- <sup>2</sup> Center for Research on Population and Health, Faculty of Health Sciences, American University of Beirut, Beirut, Lebanon
- <sup>3</sup> Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, USA
- <sup>4</sup> Leibniz Institute of Vegetable and Ornamental Crops, Großbeeren, Germany
- <sup>5</sup> Zero Hunger Lab, Thaer-Institute, Humboldt-University of Berlin, Berlin, Germany

increasing per capita caloric intake, household savings and assets, agricultural production and income, dietary diversity and alleviating household food insecurity and hunger (Salti et al., 2022; Kurdi, 2021; Schwab, 2019; Tranchant et al., 2019; Aker, 2017; Doocy & Tappis, 2017; BRAC, 2016). However, such interventions, although effective, are not sustainable in the long-term since they require consistent high levels of humanitarian funding flows and assistance on a frequent basis. On the other hand, agricultural support has the potential to build resilience and maintain and restore food security and enhance the welfare of conflict-affected populations (Bozzoli & Brück, 2009). Evidence from developing settings show that farming activities improve crop diversity and positively impact food self-sufficiency, a key factor underlying food availability (Waha et al., 2018). Moreover, small-scale agricultural interventions improve production and consumption of healthy food such as vegetables at the household level (Baliki et al., 2019) and the impacts are sustainable many years after programs end (Baliki et al., 2022; Ruel & Alderman, 2013; Ruel et al., 2018). Thus, smallholder agricultural support has the potential to improve food security and dietary diversity in conflict settings through

<sup>&</sup>lt;sup>1</sup> ISDC - International Security and Development Center, Berlin, Germany

increasing the consumption of own crop produced or generating income by selling their produce (Puri et al., 2017; Ruel et al., 2018). However, despite dearth evidence examining this impact in conflict settings, Puri et al. (2017) and Kayaoglu et al. (2023) stated the possibility of generating comparable and rigorous evidence in conflict settings.

In fact, the State of Food Security and Nutrition in the World report called for a greater attention to sustainable household food security and nutrition in conflict settings (SOFI, 2018). However, it remains unclear whether direct agricultural asset transfer interventions such as the provision of vegetable kits and tools are causally effective in achieving stronger food and nutrition security, particularly because such asset-building approaches typically address long-term development objectives rather than short-term emergency needs support (Puri et al., 2017). There is also a lack of evidence on the sustainability of the impacts of small-scale agricultural interventions in conflict-settings (Al Daccache et al., 2024; Baliki et al., 2023a). Even more scant evidence exists on if and how agricultural support reduces the reliance of households in using harmful coping strategies to deal with food shortages (Baliki et al., 2023b).

In this paper, we fill these three knowledge gaps by studying the short- and medium-term impacts of a vegetable support package on food security. Specifically, we analyze the impacts of a small asset transfer on the consumption of different nutrient rich-food groups, dietary diversity, and the use of adverse coping strategies in war-time Syria. We use panel household survey data from a quasi-experimental impact evaluation collected before any intervention occurs as well as one-year and two-years post intervention, analyzing these with fixed-effect regression models.

Our analysis reveals that vegetable intervention significantly improves food security in the short- and mediumterms. More specifically, the intervention directly increases the consumption of vegetables. Indirectly, the consumption of other nutrient-rich food groups such as root tubers, fruits, eggs, pulses and nuts, milk, and oil and fat also increases significantly. However, the treatment was not sufficient to reduce the use of harmful coping strategies employed by households to deal with food shortages, thus resilience is not attained.

Our paper contributes to the literature on food security in conflict settings in three ways: First, we present novel evidence on what works in conflict-affected settings, which is key considering that the global burden of food insecurity and hunger occurs in such contexts. Second, this paper also examines how agricultural intervention impacts food security in the short and medium terms. Third, we also examine the impact of agricultural intervention beyond food security, to assess the short and medium-term impact on household resilience. This is particularly important given the complexity of intervention design and implementation in challenging settings, especially that lessons on whether agricultural interventions can improve food security cannot be generalizable or transferable from stable developing settings.

The rest of the paper is structured as follows: The next section describes the intervention under study and its theory of change. Section 3 describes the study design and data. Section 4 reports the methodology. Section 5 presents the results. Section 6 discusses the findings.

#### 2 Intervention and theory of change

We investigate the impacts of a vegetable intervention package that was implemented by FAO in Syria as part of the larger agricultural emergency support program. The overall program ran from 2018 until 2021 and provided various agricultural inputs including in addition to the vegetable package, poultry kits, livestock vaccination, beekeeping and irrigation rehabilitation (Baliki et al., 2023a). Program beneficiaries received only one type of support. The vegetable package, which is the main intervention of interest for this paper, reached 3,400 households residing in five Governorates in Syria (Al-Hasakah, Aleppo, As-Sweida, Deir-Ez-Zor, and Quneitra), and included vegetable seeds, tools, and drip irrigation kits. The distribution of the vegetable package took place in Autumn 2018 before the sowing of vegetables in Syria. Generally, the program prioritized targeting vulnerable rural farmers with one or more of the following characteristics: (i) Households headed by women (ii) Unemployed young men susceptible to the appeal of armed groups; (iii) Small-scale farmers who lost their productive assets and/or lack access to inputs.

We hypothesize that the provision of vegetable kits will immediately increase access to quality seeds, which in turn, increase vegetable production at the household-level in the short-term. Second, the increase in vegetable production will contribute to an improvement in the consumption of nutritious and diverse food groups, either directly by consuming the vegetables produced or indirectly by generating income and increasing the ability to purchase previously unaffordable food from selling the surplus of vegetables produced. This is crucial for establishing and maintaining the supply of sufficient and nutritious food which strengthens householdlevel food security. We also hypothesize that the intervention will reduce the reliance of households on harmful coping strategies to deal with food shortage.

The Syrian conflict began in 2011 and caused the displacement of more than six million Syrians mostly from rural areas that depended on agriculture for livelihood. Although conflict affected the country as a whole, its impact varied significantly across governorates. For instance, Al-Hasakah and Deir-ez-zor governorates have experienced widespread conflict-related violence, displacement and massive destruction of infrastructure while As-Sweida and Ounaietra were relatively less affected by conflict. Yet, the latter have still experienced sporadic violence and insecurity. Hama and particularly Homs, have experienced prolonged sieges and widespread devastation as a result of conflicts and airtrikes, restricting food access and forcing the displacement of millions of civilians. This variation of the impact of conflict underscores the complex and heterogeneous nature of the conflict's effects on different governorates over time. As a result of severe economic and infrastructure damages, agricultural production has dramatically dropped especially for wheat, barley and vegetable crops (Jaafar et al., 2015). In addition to the lack of security in most governorates, Syrian agriculture suffered from a drastic increase in fuel prices with severe destruction of infrastructure and irrigation systems (Jaafar et al., 2015). More recently, despite ceasefire and reductions in active conflict, the economic impacts of the conflict coupled with the recent pandemic have continued to increase vulnerability of rural populations, threatening the lives of over half the population (WFP, 2020). It is in this context that this intervention has been implemented to improve availability and access to agricultural inputs and vegetable crops amidst the devaluation of the Syrian currency, the restricted access to water and land, the hyperinflation of food and fuels, and the extreme and poor weather conditions (OCHA, 2016).

#### 3 Research design and data

We use a quasi-experimental approach comparing households from villages that received the vegetable intervention to a control group of households from nearby villages that did not receive the intervention. This quasi-experimental design allows us to infer the causal impacts of receiving the program activity. With the control group, we can ensure that any changes we observe among the treatment group over time are the result of receiving the vegetable support intervention.

#### 3.1 Sampling strategy

This study is part of a larger program that delivered different types of support in addition to vegetable kit intervention. In this paper, we only focus on households who received vegetable kit support, which includes the following seed kit: 1.5 g of tomato, 30 g of cucumber, 3 g of eggplant, 1.5 g sweet pepper, 2.5 kg of broad bean, 30 g of spinach, and 10 g of lettuce. The eligibility criteria for vegetable support is similar to the beneficiaries and their control households and include vulnerable small-scale farmers who are affected by the ongoing crises. Households were selected based on their access to or ownership of arable land. Their land must be within 500–1000 square meters. In addition, agriculture

must be the main source of income to beneficiary households, and beneficiary farmers must be the breadwinner of their household, and without a steady source of income. The intervention prioritizes women-headed households and household members with disability.

Based on this design, our baseline sampling strategy included, in the first instance, identifying potential beneficiaries per sub-district who will receive the vegetable kits, which were pre-selected in close coordination with the implementation team. We then drew samples from these subdistricts ensuring that the sample size at the sub-district level is proportional to the number of the identified beneficiaries. We then randomly selected a set of treatment villages from the list within each of the targeted sub-districts. The enumeration team was provided with an alphabetic list of the preselected beneficiaries and randomly selected every second household from the list to take part in the study. Whenever beneficiaries could not be reached, the team then identified respondent households based on the same targeting eligibility criteria and randomly selected households for interviews until they reached the designated sample size per village.

Control villages and control households, however, were selected during the field-work at baseline. We conducted an extensive training of enumerators to select control villages similar in number and size to the pre-identified beneficiary villages within each sub-district. In addition, enumerators had a detailed list of beneficiary households that includes their characteristics and the eligibility criteria for which they were selected. Then, in each of the control villages, household participants were selected based on the same eligibility criteria that was used for the selection of beneficiaries in the treatment villages (e.g. vulnerable small-scale farmers particularly women headed households or members with disability, household have access to or own arable land, rely on agriculture as a main source of income, beneficiary farmers are the breadwinner of the household and have no steady source of income). This quasi-random selection process of the treatment and control villages ensures that we have a minimum balance between the control and treatment villages (and households) in terms of household characteristics, as well as accessibility, geography, and agro-climatic conditions. However, the selection of control villages and households is not optimal, and thus, we opt to match beneficiaries and non-beneficiaries using propensity score matching to overcome imbalances at baseline.

Another reason for the baseline imbalances observed in the control and the beneficiary groups is attributed to the difference in the initial selection of beneficiaries into different intervention arms at the beginning of the program. In fact, this study is part of a broader multi-arm program that selected participants to a specific intervention based on a set of different eligibility criteria pre-defined by the implementation team. In this paper, we focus on beneficiaries

Survey	Treatment	Control	Total
November 2018 (baseline)	235	699	934
January 2020 (one-year post-intervention)	235 (0%)	631 (9.7%)	866 (7.2%)
January 2021 (two-years post-intervention)	229 (2.5%)	663 (5.1%)	892 (4.5%)
Panel sample with data from the three waves	229 (2.5%)	618 (11.5%)	847 (9.3%)

The percentages in parentheses represent the household attrition rate compared to baseline. Out of the 847 observations across all three panel waves, we have complete information on all variables from 826 households

who received the vegetable intervention and all the control households surveyed, which could potentially lead to differences in the baseline balance between the intervention and control households.

#### 3.2 Data

As part of the quasi-experimental design, we followed up with the same treatment and control households in all future waves. Households were assigned a unique identifying number at baseline, which was used in future waves to enable tracking households, and to ensure that surveys can be merged appropriately into a panel dataset. This panel structure ensures that any changes detected in the analysis are accurately captured and not confused with other changes among households and villages during the implementation period.<sup>1</sup>

Data were collected at three time points through a panel household survey: (1) in November 2018, before the start of the intervention (2) in January 2020, one year after the implementation of the intervention, and (3) in January 2021, two years after the end of the intervention.

The initial baseline sample includes 934 households from 173 villages that were followed-up after one and twoyears post intervention, from which 235 households from 51 villages were treated and 699 households from 122 villages were control. Measures were taken during the data collection to minimize household attrition over time. As shown in Table 1, attrition rates were minimal, with 7.2% between baseline and one-year post-intervention and 4.5% between baseline and two-years post-intervention. Households who were not available at the one-year wave, were also approached again in the two-year wave, which explains why the attrition rate in the second post-interventions wave is smaller (4.5% two-years post-intervention compared to 7.2% at one-year post-intervention). For the analysis, we only use households that appeared consistently across all three waves. In total, the panel dataset includes 229 beneficiary households and 618 control households, constituting an attrition rate of around 9.3% from baseline. After dropping the missing data for socio-demographic characteristics, the final panel that was used for the analysis includes 210 beneficiary households and 579 control households.

We held the enumerator training at baseline before the start of the data collection. Trained enumerators conducted interviews using paper-based questionnaires, followed by data entry using Microsoft Access 2019. The interview was conducted mainly with the head of the household. The enumerators explained the purpose of the study and the household head provided their verbal consent to take part. Participation was voluntary and households could opt out of the study at any time. The questionnaire included several modules: household head profile; agricultural land holding and access; livestock ownership, access to agriculture and livestock input market; household dietary diversity and food consumption score; household coping strategies and exposure to shocks.

#### 3.3 Main variables

This analysis focuses on two main outcome variables of food insecurity: The Food Consumption Score (FCS) which captures access and consumption of various food groups and the Reduced Coping Strategy Index (RCSI) which captures the use of harmful coping strategies employed to deal with food shortage or money to buy food.

First, the FCS, developed by the World Food Program, is a robust measure of food security and has been used frequently in the past two decades, particularly in humanitarian settings (Kennedy et al., 2010; Wiesmann et al., 2009). The indicator measures both the types of food groups consumed and the frequency of consumption in the past seven days. Each food category is weighted by a pre-specified multiplier as shown below and the overall indicator takes a value between 0 and 114, where the higher the index to stronger the food security.

$$FCS = starches_d * 2 + pulses_d * 3 + veg_d$$
$$+ fruits_d + meat_d * 4 + dairy_d * 4$$
$$+ fats_d * 0.5 + sugar_d * 0.5$$

<sup>&</sup>lt;sup>1</sup> It is important to note that the research design was developed to also examine other agricultural intervention arms that were conducted under the same program. We excluded these as our study focuses on the provision of vegetable kits, however we used the full sample in the control group.

In the equation  $x_d$  denotes the number of days out of seven each specific food group is consumed. For example, if households consumed all food groups in all seven days then the maximum theoretical number would be 114, while if they consumed no food at all in all seven days, then the theoretical minimum number is 0.

Second, the RCSI, which was used primarily to examine the indirect severity of food insecurity experienced by households, contains information on the harmful strategies households had to employ in the past 30 days to cope with a shortage of food (Maxwell et al., 2003; WFP, 2019). These include relying on less preferred or less expensive food, relying on help from relatives or friends, reducing the number of meals eaten a day, limiting portion size at meals, and restricting adult consumption for children to eat. In our RCSI index we use all the strategies apart from restricting adult consumption for children to eat, as it was dropped in later waves due to local sensitivity concerns. Moreover, to make the indicators comparable to FCS in terms of time reference we multiplied each coping strategy by 7 and divided by 30. Therefore, our RCSI index is calculated as the sum of the number of days out of seven, each of the four coping strategies was employed and multiplied by weights as follows:

RCSI = rely less on preferred food\_d \* 1 + rely on help from friends and relatives\_d \* 2 + number of meals eaten per day\_d \* 1 + limit portion size\_d \* 1

where X\_d takes denotes the number of days this strategy was used in the past 7 days. Therefore, the RCSI index takes a value between 0 and 35. A higher RCSI score indicates an increase in household food insecurity.

Demographic variables included household head age, gender, occupation, education, residence status of the family, and household size. For education of the household head, participants reported the highest level of education attained and the options included "none", "primary/elementary", "secondary/high school", and "tertiary education". For household head occupation, the question inquired about "the main occupation and proportion of livelihood contributed from crop farmer or herder's occupation". Individuals were asked about the residence status of the family and the options included "displaced", "resident", and "returnee". Household head size included the total number of children, adults, and older adults in the household.

Exposure to shocks was quantified using the following question: "in the past 12 months, have you or any household member experienced any of the following shocks?" Response options included, but not limited to, drought, security circumstances/conflict, and unusually high level of crop pests and diseases. Questions inquired about agricultural inputs included whether the individual used the following in the past 12 months: pesticide, organic fertilizer, inorganic fertilizer, or hired labor. Livestock ownership was determined by the following question: 'How many [livestock] do you have at the moment?' for each of cattle, goats, sheep, and chicken. The answers were summed, and a dummy variable was created representing "1" if the household owns at least one livestock and "0" otherwise. For land ownership, the question encompassed whether the household owns any of the irrigated or rainfed land during the most recent production season of the year. To measure water access, the question included whether households face any constraints related to access to, and use of, water for irrigation.

#### 4 Methodological approach

In the absence of a randomized controlled trial to assess the impact of vegetable intervention, we used propensity score matching (PSM) and fixed effect models to account for potential selection bias (Luo et al., 2010). Specifically, we used the so-called "greedy" one-to-one nearest neighbor propensity score matching followed by regression adjustment, which was suggested to be a stronger approach for estimating causal impacts as compared to regression on an unmatched sample (Stuart & Rubin, 2008). We used the greedy PSM to match households based on their propensity scores, which estimate the probability of receiving the support. Using this approach, households are matched oneby-one and each household will be paired with the closest match in propensity score (Austin, 2014). Therefore, in order to create a counterfactual to compare households that have received the intervention (beneficiary group) to those who have not received the intervention (control group), and account for any imbalances which could affect estimation of program impact, we matched households from control and beneficiary groups based on observed covariates before the intervention (Stuart & Rubin, 2008; Greevy et al., 2004). This allows for the assumption that any observed difference in the outcomes between the two groups can be attributed to the intervention. The outcome variables, even if collected at baseline, were excluded from the matching process as we only focus on confounding variables, those related to the treatment assignment and the outcomes (Rubin, 2007; Stuart & Rubin, 2008).

For the main analysis, we matched on baseline sociodemographic characteristics, shocks occurrence, and agricultural factors. The 1:1 matching approach specifies that households in the intervention group are matched with one household from the control group. This matching approach is particularly effective when household's data are collected over different time points (Stuart, 2010). While this approach has been argued to estimate the average treatment effect of the treated by discarding the unmatched control, this method maintains the same sample size since all the treatment households are matched to a corresponding control (Stuart, 2010). We used 1:1 matching without replacement which yielded high covariate balance as compared to 1:1 with replacement and is particularly strong for our design where we have a large number of control groups. For robustness check, we ran the same model using the three more specifications: (1) 2:1 nearest neighborhood without replacement, (2) 2:1 nearest neighborhood with Mahalanobis distance without replacement, (3) 3:1 nearest neighborhood with replacement, and (4) difference-in-difference model, to ensure similarities in the estimates as compared to 1:1 nearest neighborhood without replacement.

Matching variables related to the outcome improve the precision of the exposure effect (Brookhart et al., 2006). However, as propensity score also aims to reduce confounding, it has been recommended to include covariates that are related to both the intervention and outcome (Caliendo & Kopeinig, 2008; Garrido et al., 2014). Consequently, the following variables were considered to influence the provision of vegetable intervention: water constraints for irrigation; agricultural land, and livestock ownership in the current production season. Other socio-demographic covariates such as household head gender, age, occupation, education, resident status, and household size, as well as shock occurrence were also included in the matching process.

For the impact analysis, we use the fixed effect ordinary least square estimation (FEOLS) of the panel data to quantify the mean impact of the program on food security. The fixed effect estimation rules out any potential confounding by unobserved time-invariant characteristics and measures changes within the household, improving the precision of the estimates (Baltagi, 2010). We estimate the following equation:

$$y_{it} = \alpha + \beta.Treat_i + \gamma_t.Post_t + \delta_t.(Treat_i * Post_t) + \lambda_i + \epsilon_{it}$$
(1)

where  $y_{it}$  is our food security outcome of individual *i* in *t*.  $Treat_i$  is the treatment assignment which takes the value 1 if a household is in the treatment group and 0 if a household is in the control group. Post, is the wave fixed effect for  $t = \{0, 1, 2\}$ . We are interested in estimating  $\delta_t$  the coefficient of interaction term between the treatment and the post-intervention period. Hence,  $\delta_1$  and  $\delta_2$  are respectively the 1-year and 2-year impacts of the treatment.  $\lambda_i$  is the set of time-invariant omitted variables and  $\epsilon_i$  the error term. Given that we are estimating an individual fixed effect model, both the constant  $\alpha$  and the coefficient  $\beta$  are dropped. After using the 1:1 nearest neighborhood without replacement, we use the matched panel dataset itself, which has a similar propensity score and similar observed characteristics at baseline between the intervention and control households, before running the FEOLS estimation described above.

#### **5** Results

We first present the descriptive findings and the preintervention balance tests between the treatment and the control group before and after matching. Second, we present the 1-year and 2-year impact findings of the vegetable kits on food security. Finally, we show that the results are robust for different matching specifications and econometric techniques.

#### 5.1 Descriptive statistics and balance tests

Table 2 shows the baseline balance between the control and treatment households before and after matching using the complete panel dataset. Before PSM adjustment, we observe that 82.5% of households in the control group are male headed compared to 66.8% of households in the treatment group, and that households in the control group are on average more educated than the treatment group. 10.8% of households in the control have secondary or higher educational attainment levels compared to 7.4% of households in the treatment group. Yet, we find that control households experienced higher levels of insecurity or conflict in the 12 months before the baseline, and the share of households in this group who faced challenges in accessing water was higher than that in the treatment group. Given that the initial selection of the treatment and control groups in the program were conducted differently both at the village and household levels, we are not surprised by the imbalances in some of the household characteristics at baseline. For example, it was more challenging to find and interview femaleheaded households in control groups. After conducting the greedy one-to-one propensity score matching, we find no more significant differences on any of these covariates, which implies that the selected households in the control group are more similar in structure to the treatment households.

After PSM adjustment, the majority of the study sample were male headed households (67%), crop farmers or herders (92%), and land owners (55%), with an average age of about 49 years. Almost one third of the sample have not completed any levels of schooling while less than 8% have completed secondary education. The average household size of the study sample included more females than males, with a mean of 3.90 and 3.50, respectively. Most of the households were residents (87%), which means that they were not returnees or internally displaced. While 58% of the households reported owning land, only 21% faced water constraints for irrigation. In the past 12 months before baseline, almost 62% of the households experienced drought, 27% experienced conflict events and 49% crop pests. **Table 2**Baseline balancebetween treatment and controlhouseholds before and afterpropensity score matching

	Before PSM Adjustment			After PSM Adjustment		
	Control	Treatment	р	Control	Treatment	р
Sociodemographic Characteris	tics of the Hou	sehold				
HHH Gender (% Male)	82.5	66.8	0.001	68.6	66.7	0.754
HHH Age*	49.5 (13.00)	49.3 (12.6)	0.789	49.4 (12.6)	49.5 (12.6)	0.914
HHH Completed Education (%)			0.023			0.666
No Schooling	21.7	30.1		32.9	29.5	
Primary	67.5	62.4		59	63.3	
Secondary+	10.8	7.4		8.1	7.1	
Male number*	3.62 (2.20)	3.48 (1.75)	0.377	3.43 (2.15)	3.50 (1.74)	0.727
Female number*	3.57 (2.21)	3.85 (2.05)	0.102	3.84 (2.4)	3.92 (2.06)	0.696
Resident (% Yes)	85.1	87.1	0.554	86.7	87.1	1.000
Agricultural Profile of Househo	old (% Yes)					
HHH is Crop Farmer or Herder	92.6	93.4	0.767	91.4	93.3	0.581
Land Ownership	62.5	56.8	0.153	55.2	56.2	0.922
Livestock Ownership	38.7	37.1	0.738	37.6	37.1	1.000
Water Constraints	28.5	21.8	0.064	21.0	21.9	0.905
Exposure to Shocks in Past 12	Months (% Yes	)				
Drought	63.1	64.2	0.833	58.6	62.9	0.424
Insecurity / Conflict	34.6	27.1	0.045	26.7	28.6	0.743
Crop Pests	46.1	47.6	0.759	49.0	49.0	1.000

For categorical and binary variables, we show the percentages; For continuous variables, we show the mean and include the standard deviation in parentheses (These variables are marked with \*). The p-value shows the significant level of the mean (standard deviation) or percentage difference between the two groups. A value of less than 0.1 implies a significant difference at the 10% level *HHH* Household Head

5.2 Average treatment effects

Table 3 shows the mean household food consumption score and reduced coping strategies index of the overall sample at baseline as well as the average treatment effects one year and

 Table 3 Impact of vegetable support on food security indicators

	Baseline mean (SD)	1- year impact estimate (SE)	2- year impact estimate (SE)	
FCS	55.49	11.76***	10.49***	
	(18.01)	(2.24)	(2.06)	
RCSI	7.78	-1.29**	-0.63	
(:	(5.46)	(0.64)	(0.65)	
n	420	1,260	1,260	
Fixed Effects	-	Yes	Yes	

The first column shows the baseline means and standard deviation of both treatment and control households. The second and third columns show respectively the coefficient (and standard errors in parentheses) of the interaction term between the respective waves (1-year and 2-year post-intervention) and treatment dummy. Both estimates are extracted from the same individual fixed effect ordinary least squares regression

Significance levels: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

two years after the end of the intervention. The mean FCS at baseline for the overall sample was 54 points, indicating an acceptable food consumption score. The mean RCSI is 7.7. The estimates in Table 3 show that the intervention increased the FCS score in the short-term, one year after the intervention by 11.8 points (p < 0.01). This is a 20% increase from baseline values. Moreover, and more interestingly, we find that the positive effect remains strong and significant two years after the end of the intervention. Households in the treatment groups have 10.5 points higher FCS 2 years after support (p < 0.01). Moreover, we find a significant short-term effect of the intervention in reducing the use of coping strategies by 1.3 points (p < 0.05) as measured by the RCSI. This is a 17% improvement in RCSI compared to pre-treatment means. However, this effect dissipates in the medium-term, two years after the treatment took place. In summary, vegetable intervention causally significantly improves food security one year after the end of the intervention, and this effect was sustained for at least two years. Onm the other hand, although households reduce the use of their coping strategies to deal with food shortages, this effect is short-lived, underscoring the limitation of such small support in strengthening resilience of households in the long-run.

	Baseline	1- year impact	2- year impact	
	Mean (SD)	Estimate (SE)	Estimate (SE)	
Cereals	6.84	0.09	-0.09	
	(0.82)	(0.11)	(0.11)	
Root tubers	2.56	0.39**	0.25	
	(1.40)	(0.16)	(0.16)	
Vegetables	3.56	0.86***	0.92***	
	(1.96)	(0.24)	(0.24)	
Fruits	1.12	0.22	0.27*	
	(1.36)	(0.16)	(0.16)	
Meat & Poultry	0.68	0.13	0.03	
	(0.64)	(0.08)	(0.08)	
Eggs	2.26	0.71***	0.31	
	(1.82)	(0.22)	(0.22)	
Fish	0.03	-0.00	0.07	
	(0.18)	(0.04)	(0.04)	
Pulses & Nuts	1.92	0.77***	0.73***	
	(1.26)	(0.18)	(0.18)	
Milk	3.34	1.20**	1.40***	
	(2.64)	(0.29)	(0.29)	
Oil & Fat	5.67	0.54***	0.60***	
	(1.75)	(0.20)	(0.20)	
Sugar	6.79	0.35*	0.10	
	(0.95)	(0.20)	0.20)	
n	420	1,260	1,260	
Fixed Effects	-	Yes	Yes	

 Table 4 Impact of vegetable intervention on the consumption of different food groups over the past seven days

The first column shows the baseline means and standard deviation of both treatment and control households. The second and third columns show respectively the coefficient (and standard errors in parentheses) of the interaction term between the respective waves (1-year and 2-year post-intervention) and treatment dummy. Both estimates are extracted from the same individual fixed effect ordinary least squares regression Significance levels: \*p < 0.1; \*\*p < 0.05; \*\*\*p < 0.01

Table 4 disaggregates the impact of the vegetable intervention by the different food groups that constitute the food consumption score. First, as expected at baseline, almost all participants consumed cereals on a daily basis, followed by sugar, oil and fats. The mean consumption of fruits, meat, poultry, and fish at baseline were very low. For example, on average, fruits were consumed around one day a week. Second, we find that the intake of most healthy foods has significantly improved one and two years after the intervention. As such, the mean consumption of vegetables, which was at 3.5 days a week on average at baseline, has significantly increased by 0.85 point and 0.92 point one and two years after the end of the intervention, respectively. Households in the treatment group are consuming vegetables one additional day per week, which

Table 5 Impact of vegetable intervention on the use of agriculture inputs

	Baseline mean (SD)	1- year impact estimate (SE)	2- year impact estimate (SE)
Pesticides	0.51	0.03	0.10*
	(0.50)	(0.06)	(0.06)
Organic fertilizer	0.14	-0.06	-0.05
	(0.35)	(0.04)	(0.04)
Inorganic fertilizer	0.42	0.06	0.06
	(0.49)	(0.05)	(0.05)
Hired Labor	0.22	0.10*	0.10*
	(0.42)	(0.06)	(0.05)
n	420	1,260	1,260
Fixed Effects	-	Yes	Yes

The first column shows the baseline means and standard deviation of both treatment and control households. The second and third columns show respectively the coefficient (and standard errors in parentheses) of the interaction term between the respective waves (1-year and 2-year post-intervention) and treatment dummy. Both estimates are extracted from the same individual fixed effect ordinary least squares regression

Significance levels: \*p<0.1; \*\*p<0.05 \*\*\*p<0.01

represents a 25% increase from baseline value. Likewise, the consumption of milk, pulses and nuts, and oil and fats has significantly increased one and two-years after the intervention, indicating an improvement in accessing food groups beyond the expected direct supply from the intervention. This could be explained by the increase in purchasing power of households to access usually unaffordable food groups. Finally, the mean consumption of eggs and root tubers has increased in the short- and mediumterm, however this effect disappears two-years post intervention. On the other hand, the interventions improved the consumption of rare food items such as fruits only two-years post intervention, indicating a strong income effect of the interventions in the medium-term.

Table 5 shows the impact of vegetable support on the use of agriculture inputs. At baseline, almost half of the participants used pesticides and inorganic fertilizers in the past 12 months, respectively. Hired labor, which was used by 22% of the participants at baseline, has significantly improved in the treatment group one and two-years post intervention by 10% points (p < 0.1). We also detect a positive impact on the use of pesticides in 2 years after the end of the intervention, however this effect is also weak (p < 0.1). We do not find any effects on the use of either inorganic and organic fertilizers, which could be driven by supply-side constraints, such as lack of availability of these inputs in local markets or access to these markets in Syria rather than a demand-side effect.

 
 Table 6
 Robustness check using other matching techniques or specifications

	1 -year impact		2-year impact	ict
	FCS	RCSI	FCS	RCSI
2:1, Nearest Neighborhood without replacement	9.32***	-0.97*	8.69***	-0.44
	(1.76)	(0.52)	(1.75)	(0.52)
2:1, Mahalanobis distance without replacement	8.26***	-0.67	7.49***	-0.09
	(1.74)	(0.52)	(1.73)	(0.52)
3:1 Nearest Neighborhood without replacement	8.68***	-0.65	8.72***	-0.27
	(1.66)	(0.50)	(1.65)	(0.50)
Difference -in- Difference	11.76***	-1.29*	10.49***	-0.63
	(2.53)	(0.67)	(2.38)	(0.81)

All columns show the coefficient (and standard errors in parentheses) of the interaction term between the respective waves (1-year and 2-year post-intervention) and treatment dummy. Both estimates are extracted from the same individual fixed effect ordinary least squares regression

Significance levels: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

#### 5.3 Robustness checks

To check the robustness of our results on food security and resilience outcomes, we match households at baseline using nearest neighbor propensity score matching (1) 2:1 without replacement, (2) 2:1 without replacement using Mahalanobis distance, (3) 3:1 with replacement, and (4) using differencein-difference linear estimation for each post-treatment wave separately (Table 6). These different matching techniques largely yielded similar results to our main 1:1 nearest neighbor matching and FEOLS estimation. The impact on FCS remains positive and strongly significant under all different specifications in the short- and medium-term with slight variation in the magnitude of the effect. The weak positive effect of the intervention on RCSI did not hold under specifications (2) and (3). Overall the robust findings emphasize the critical role of vegetable support programs on sustainability improving food security and dietary diversity.

#### 6 Discussion

Our study makes contributions to three literatures, namely on food security, farm productivity and resilience, all in the context of violent conflicts. We will discuss these findings and contributions in turn.

First, our study demonstrates that vegetable support programs in crisis settings can have strong positive shortand medium-term impacts on household food security. Our results are largely consistent with findings from previous work conducted in stable developing settings, which show that agricultural support has an integral role in improving food consumption, dietary diversity, and food security (Kurdi, 2021; Baliki et al., 2019; Schwab, 2019; Tranchant et al., 2019). Particularly, we find a strong impact on the consumption of food groups that were dramatically low at baseline such as vegetables, pulses and nuts, and animalbased products including poultry, meat, and eggs. This, again, is in line with previous studies from stable settings, which show that small-scale agricultural support directly improves food access and auto-consumption of crops produced (Baliki et al., 2019; Ruel et al., 2018). In addition, such interventions have the potential to improve household income through increasing sales of surplus harvest to buy usually unaffordable food groups such as animal source foods (Baliki et al., 2019; Ruel & Alderman, 2013; Ruel et al., 2018). Moreover, our results show consistent and strong impact sustainability (at least two-years) of small vegetable support in protracted conflict settings, which underscore the potential of incremental levels of support in improving food security and the consumption of healthy food (Baliki et al., 2022). However, considering that exposure to conflict shapes production and consumption behavior (Brück et al., 2019b; Martin-Shields & Stojetz, 2019; Van Daalen et al., 2022; Verwimp & Munoz-Mora, 2018; Verwimp et al., 2019), more research is needed to investigate the role of contextual factors such as insecurity along their mechanisms of actions to better understand the complete chain from household vegetable production via subsistence consumption to better nutrition, especially on how production influences diets in conflict-affected settings.

Second, we show that vegetable support contributes to improving farm productivity in the short- and medium-term by increasing the affordability of hired labor. This finding is in line with previous work undertaken in stable low- and middle-income countries, which demonstrates a positive effect of nutrition-sensitive agricultural intervention on agricultural inputs and practices (Ruel et al., 2018). Although the findings align, the mechanisms through which the intervention impacts the use of agricultural inputs substantially differ across the two settings in two ways. First, it is likely that the intervention, its underlying mechanisms, and the use of agricultural inputs are directly affected by the severity of the conflict itself. Second, conflict exposure, which leads to forced displacement, shapes farmers' decision-making and risk-taking behaviors (Moya, 2018). Despite these differences, our finding confirms the importance and benefits of small-scale vegetable support to increase farmer's willingness to invest in their own land by fostering affordability and access to hired labor, including in insecure settings. However, to fully understand how vegetable support can increase the use of agricultural inputs and under such circumstances, future interventions in crisis settings covering a broader range of agricultural activities, multiple types of inputs, and output market structure and access need to be studied (Al Daccache et al., 2024).

Third, our results indicate that the intervention alone is not sufficient to generate a meaningful impact on household resilience to shocks in the long-run. As resilience is a multifaceted phenomenon, it is unlikely that a single component agricultural intervention improves resilience (Brück et al., 2019b). Therefore, combining agricultural support with other integrated programs in protracted humanitarian programs may be required if household resilience to shocks is to be strengthened. Our study contributes to the resilience literature by demonstrating that small-scale vegetable support can improve the use of agricultural inputs and food security primarily by increasing the consumption of high quality and nutritious foods in conflict settings. However, given that conflict alters intra-household dynamics and increases vulnerability and the use of harmful coping strategies (Brück & d'Errico, 2019), it is imperative to assess the determinants of resilience within households to identify who benefits the most and the least from these interventions in future research. More broadly, given that violent conflict intensifies intra-household variation, future research should be extended to assess intra-household heterogeneity as well as what operational aspects, mechanisms, and context improves food security and resilience to the most vulnerable in conflict-affected communities. Finally, future research may wish to differentiate more closely the role of contextual factors such as access to and availability of markets in times of insecurity, as these are likely to weaken in times of violent conflict.

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**Data availability** Data is available from the authors upon reasonable request.

#### Declarations

**Ethics approval** It was granted Institutional Review Board (IRB) Exemption from the IRB of the American University of Beirut (AUB) and de-identified data were used in secondary data analysis by AUB researchers.

**Consent to participate** All participants provided verbal consent prior to the study and were informed about their right to withdraw from participation at any time.

Competing interests The authors declare no conflict of interest.

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**Professor Hala Ghattas** is Associate Professor at the Arnold School of Public Health, University of South Carolina. Her research explores the social and structural determinants, and health consequences of both under- and over- nutrition in the contexts of the global nutrition transition, and regional conflicts in the Middle East.

**Professor Tilman Brück** is a development economist studying the behavior and the welfare of poor and vulnerable households in conflict-affected, fragile and humanitarian emergency settings and developing research methods for conflict settings. He is the Founder and Director of ISDC – International Security and Development Center, Professor at Humboldt-University of Berlin and Head of the Research Group "Economic Development and Food Security" at the Leibniz

Institute of Vegetable and Ornamental Crops.





**Dr. Ghassan Baliki** is the Director of the Welfare Research Program at ISDC and Guest Researcher at Thaer-Institute at Humboldt University of Berlin. He obtained his PhD from Humboldt-University of Berlin, where he studied violent conflict dynamics in Syria at the micro-level. Ghassan's research focuses on the interlinkages between violent conflict, fragility, welfare and food security at the micro-level.

**Melodie Al Daccache** is a researcher at the Welfare Research Program at ISDC, and a PhD candidate at Humboldt-University of Berlin. Her research focuses on food security, nutrition, women's health, and livelihoods in developing contexts, especially in crisis-affected settings.