World Vegetable Center

Home-grown school feeding and school gardens to improve children's dietary preferences and practices: Results from Eswatini

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Cover picture: Thumbs up! Children from Boyane Primary School in Eswatini enjoy tasting and discussing different recipes which include traditional African vegetables, and noting their preferences so the school cooks know what they like.
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Home-grown school feeding and school gardens to improve children's dietary preferences and practices: Results from Eswatini

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Summary

Nutrient-dense traditional African vegetables can contribute to healthy diets in sub-Saharan Africa, where many countries face complex nutritional challenges, in a context of climate change and resource scarcity. For children, vegetables can diversify school meals which typically consist of starchy staple foods and legumes. Production of traditional African vegetables in school gardens can raise children's awareness of and interest in these vegetables, while sourcing vegetables from nearby smallholder farmers ('home-grown school feeding') can strengthen local livelihoods.

This study in 24 primary schools across Eswatini evaluated the impact of improved school gardens and home-grown school feeding programs on children's knowledge, enjoyment and intake of vegetables, with a focus on traditional African vegetables. It was funded by the Ministry of Agriculture and Ministry of Foreign Affairs, Taiwan, through the Taiwan Africa Vegetable Initiative. Eight schools received gardening support and training, and eight received gardening support, training and, additionally, a supply of locally-grown vegetables for use in school meals. A further eight schools received no project interventions and were used as a control group.

None of the schools grew traditional African vegetables before the project started. One year later, teachers in intervention schools reported five different traditional African vegetables being grown, the most common being Ethiopian mustard, amaranth and okra. Children's knowledge about gardening practices was low at the baseline, with a modest improvement in all schools over time. Knowledge about compost improved substantially from very low baseline levels – with significantly greater improvement in intervention schools.

Overall, children were more familiar with fruits and global vegetables than traditional African vegetables, based on their ability to name items in photographs and their reported familiarity with the taste of pictured items. By the end of the study, more children in intervention schools were able to correctly name traditional African vegetables, compared to those in control schools. Greater numbers of children enjoyed fruits and global vegetables, than the number enjoying traditional African vegetables - but being served locally-grown vegetables in school meals did appear to have a positive effect on their acceptability to children.

Most vegetables supplied to school canteens by local farmers were traditional African vegetables, mostly leafy greens. Supply varied between schools and over time, with an average weekly quantity of 27 kg, and an average supply frequency of 1.3 times per week. Despite challenges in assessing diets based on children's own recall and recording, we found a significantly greater increase in dietary diversity and intake of green leafy vegetables over time among children in schools receiving vegetables from local farmers, compared to control schools.

Future research, through discussions with children, caregivers and school staff, will be important to better understand children's food preferences and the barriers to growing and regularly serving a range of vegetables in schools. To improve future evaluations, it may be useful to involve school canteen staff in recording foods served in school meals, and for periodic follow-up with school teachers to better capture garden activities across the year. Overall, our study's findings support the additional impact of a supply of vegetables from local farmers on increasing children's vegetable consumption through school meals, beyond the effects of school-grown produce.

1. Background

As in many countries in sub-Saharan Africa, food and nutrition insecurity remains an ongoing challenge in the Kingdom of Eswatini. Around 60% of the population of Eswatini lives below the national poverty line (World Bank, 2020). Over 183,000 people, or 16% of the population, were estimated to face high levels of acute food insecurity during the period of July-September 2022 (IPC, 2022). This was linked to rainfall variability, high food prices due to fuel price rises, and continuing impacts of the Covid-19 pandemic, including loss of livelihoods due to movement restrictions. Current information on the nutritional status of children in Eswatini is limited, with the most recent available nationally-representative survey conducted in 2014. This survey reported one in four children under five years of age (26%) were affected by stunted growth, while close to one in ten (9%) were overweight (CSO and UNICEF, 2016).

Nutrient-dense traditional African vegetables can make an important contribution to meeting children's nutritional needs, by diversifying school meals typically consisting of starchy staple foods and legumes. In addition, they can make an important contribution to improving climate-resilience of food production through crop diversification. Traditional African vegetables include those that are part of local food cultures after generations of local seed-saving (van Zonneveld et al., 2021). Many are highly nutritious and can be readily incorporated into existing farming systems because they require little space and fit within short crop rotations (Schreinemachers et al., 2018; van Zonneveld et al., 2020). These vegetables can also be an attractive source of income for male and female farmers (Dinssa et al., 2016; Weinberger and Pichop, 2009). Despite these multiple benefits, access to traditional African vegetables is limited by sub-optimal seed supply and vegetable production technologies, and low awareness of their nutritional importance.

School feeding programs have been described as targeted social safety nets, providing educational and health benefits to vulnerable children, increasing school enrollment, reducing absenteeism, and improving food security at the household level (World Bank, 2012). Globally, school feeding programs have become a widely-used governmental mechanism to address undernourishment among children, and improve longer-term nutritional outcomes and cognitive development (Kristjansson et al., 2016; Buttenheim et al., 2011). Most existing school feeding programs center on the provision of non-perishable items such as grains, pulses and oils, which can be centrally purchased and distributed. For many, a key challenge is the inclusion of fresh produce such as fruit and vegetables. Recent years have seen an expansion of the goals of school feeding programs to include local smallholder farmers as food suppliers, strengthening their livelihoods and increasing the availability of fresh produce for school meals (FAO and WFP, 2018). Such programs are known as 'home-grown school feeding programs.' Objectives vary between countries, but they are characterized by the sourcing of fresh produce from nearby communities (Gelli et al., 2010; Shresta et al., 2020).

An alternative approach to sourcing fresh produce for school meals is to produce it on school grounds through a school garden. Supply of fruits and vegetables from school gardens is typically limited, with school gardens primarily serving as an educational tool to raise children's awareness of and interest in fruit and vegetables, and nudge their food choices toward healthier eating (Schreinemachers et al., 2020). Several studies have assessed the impact of school gardens in lower-income countries. For instance, Schreinemachers et al. (2017a, 2017b, 2020) conducted clustered randomized controlled trials to assess the effect of school gardens in Bhutan, Burkina Faso and Nepal. Findings show that school gardens coupled with nutrition education improved children's nutrition knowledge and attitudes toward healthier foods, but this did not always translate into increased fruit and vegetable consumption, at least in the short-term (Schreinemachers et al., 2019).

Similar findings are reported in high-income countries, where school garden programs have been found to be more effective in enhancing knowledge and changing attitudes than increasing fruit and vegetable intake (Ohly et al., 2016; Blair, 2009; Christian et al., 2014). This implies that school gardens themselves may not be

sufficient to influence dietary behavior, but a combination of school and community-level initiatives may yield better outcomes. For instance, initiatives to support greater availability of fruits and vegetables, and increased knowledge at community level may have positive effects on children's consumption behavior (Schreinemachers et al., 2020). A combination of school feeding programs and school gardens is a more holistic approach that could lead to increased consumption of healthy foods, but there is no evidence of synergetic effects to date.

2. Study design

The first phase of the Taiwan Africa Vegetable Initiative (TAVI) was a three-year project (2021-2023), funded by the Taiwan Council of Agriculture and the Taiwan Ministry of Foreign Affairs. It sought to safeguard vegetable biodiversity to create strong foundations for more resilient food systems in Africa, with an initial focus on Benin, Eswatini, Madagascar and Tanzania. Of the multiple activities supported by this project, the present study focuses on a school garden and home-grown school feeding initiative in Eswatini. It is led by the World Vegetable Center (WorldVeg), in collaboration with the Eswatini Ministry of Agriculture and the Ministry of Education and Training.

Interventions

The study included three interventions.

1. Support for growing traditional African vegetables in school gardens, as an educational tool for students. The project helped to build teachers' capacity to establish and maintain school gardens, and provided quality seeds of selected vegetables to schools. Focal vegetables in this project included amaranth, African nightshade, Ethiopian mustard, jute mallow, African eggplant, okra, pumpkin and tomato. Ongoing monitoring and technical assistance were provided by the project team, together with agricultural extension officers from the Ministry of Agriculture. Vegetables produced in school gardens were intended to be served in school meals to all students.
2. Developing and delivering a ten-week curriculum on nutrition and gardening. The curriculum emphasized hands-on training conducted in school gardens. It included general nutrition knowledge, identification of common nutritious vegetables, preparation and consumption of healthy diets, and good agricultural practices for vegetable production. This component of the intervention targeted Grade 6 students, who were anticipated to be ambassadors of the training program beyond the classroom.
3. Strengthening capacity of champion farmers to produce safe and nutritious vegetables to supply school kitchens. These local farmers were intended to supplement produce harvested from school gardens, and were contracted by the project to produce and sell traditional African vegetables to schools through the national school feeding program. Champion farmers received seed kits containing ten different traditional African vegetables, and technical assistance from the project team and government agricultural extension officers, and were supported to identify alternative markets for surplus produce. Project funds were used to pay farmers for vegetables supplied, while a financial model and operation plan to ensure a sustainable supply of vegetables to schools was developed.

This study aimed to assess the combined impact of school garden and home-grown school feeding interventions on dietary preferences and practices among school children. This report presents findings from an evaluation of this project, based on baseline and endline surveys in intervention and control schools, to assess, quantify and test the significance of changes in children's:

- awareness of selected vegetables and fruits;
- preferences for selected vegetables and fruits;
- knowledge, attitudes and practices relating to food and nutrition;
- vegetable and fruit intake at school and home, in combination with a home-grown school feeding program.

The study design included a control group (receiving no project interventions) and two treatment groups, as shown in Figure 1. Schools receiving all three interventions (i.e. support for growing traditional African vegetables in school gardens, training on nutrition and gardening, and school canteens supplied with vegetables by local farmers) are referred to as 'TAVI-3' schools in this report; and those receiving two interventions (i.e. support for growing traditional African vegetables in school gardens, training on nutrition and gardening) are termed 'TAVI-2' schools.

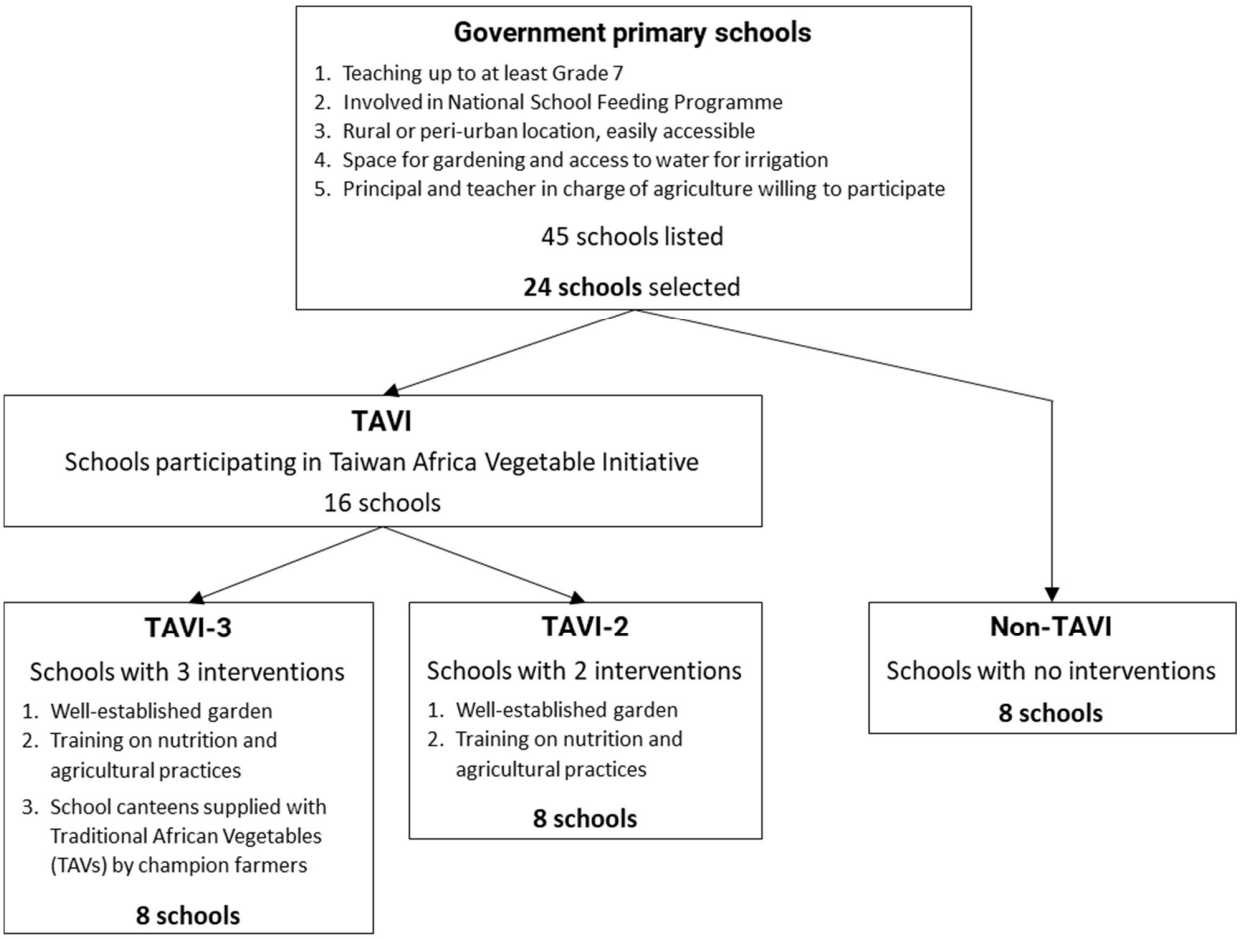

Figure 1. Classification of schools in this study, with two treatment groups and one control group.

Study sample

This study was conducted in selected primary schools in Eswatini between May 2022 and June 2023. A list of eligible schools was created in consultation with officials from the Ministry of Education and Training in Eswatini. To be eligible, schools were required to be a government primary school teaching at least up to Grade 7, be involved in the national school feeding program, be located in accessible rural or peri-urban areas, have space for gardening and access to water for irrigation, and be willing to participate in the project. A list of 45 eligible schools across all four administrative regions in the country, was provided by the Ministry of Education. Allocation of schools to treatment arms was stratified by region, with two schools from each region assigned to control, TAVI-2 and TAVI-3 groups (Figure 2). An initial allocation was done at random, with two TAVI-3 schools from Manzini Region re-allocated to control groups (and two control schools re-allocated to TAVI-3 groups) based on a decision that they lacked resources to support improved school gardens.

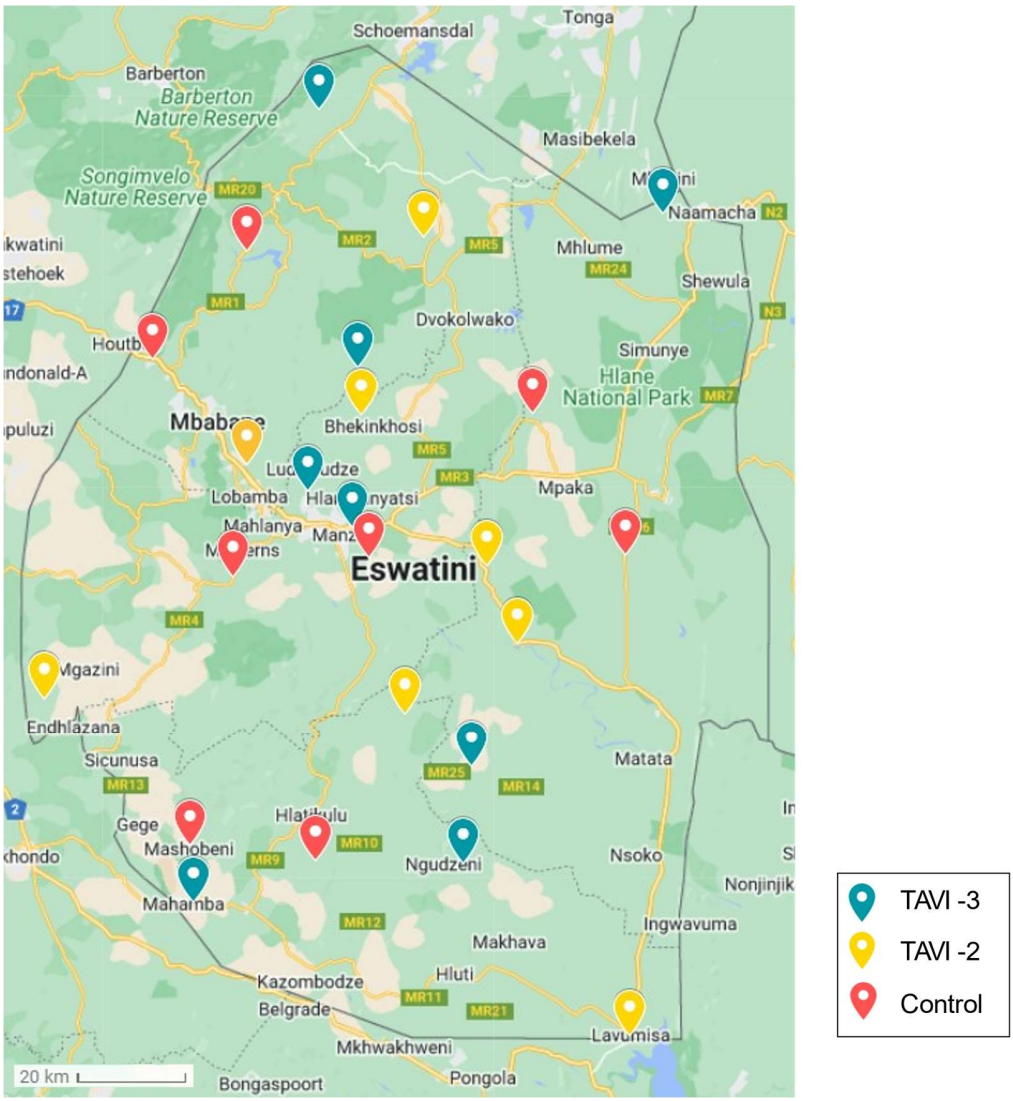

Figure 2. Location of sampled schools across the country (Source: Google MyMaps).

3. Data collection and analysis

Data collection

Two rounds of data were collected: a baseline in May 2022 and endline in June 2023. Power calculations were used to estimate the number of children to be selected in each school (Gertler et al., 2016; Spybrook et al., 2011). A total of 1,105 school children participated in data collection (746 from two treatment groups of schools and 359 from the control schools), with an average of 46 children per school. The primary data collection tool was a structured questionnaire for school children. This collected information on knowledge, attitudes and practices about food, nutrition and agriculture; their awareness, taste preferences and intake of fruits and vegetables; and socioeconomic and demographic characteristics of children and their households.

Children completed paper-based questionnaires, under the guidance of trained enumerators in a classroom setting. Enumerators provided question-by-question instruction on the meaning of each question and how to

record responses. Additionally, one teacher from each of the schools completed a survey to provide information on school garden production, school meals and general characteristics of schools. Champion farmers provided information on the quantities of vegetables supplied to schools on a monthly basis.

Data analysis

An overview of variables used in this study is provided in Table 1, below. Descriptive analyses were used to characterize the study sample, overall and by intervention groups. Children for whom endline data was missing were excluded from the analysis (*n* = 116 children; attrition rate of 10.5%). A difference-in-difference (DiD) estimation method was used to compare the average change in each outcome indicator, and other variables of interest, over time between intervention and control groups, before and after the intervention. Three separate models were estimated: one comparing TAVI schools with three treatments (TAVI-3) and control schools, another comparing TAVI schools with two treatments (TAVI-2) and control schools, and a third model comparing all TAVI schools (TAVI-2 and TAVI-3) with control schools.

Table 1. Outcome variables included in this study

Indicator	Details
School garden participation – general	Work in school garden (yes / no)
School garden participation – specific activities	Involved in soil preparation (yes / no)
	Involved in making plots (yes / no)
	Involved in sowing or transplanting (yes / no)
	Involved in fertilizer application (yes / no)
	Involved in other garden activities (yes / no)
School garden participation frequency	Usual number of times worked in garden per week
Vegetable production in schools – specific	Free listing of specific items grown; binary variables created
Knowledge – gardening practices	Percentage correct, of maximum 14 points
Knowledge – compost	Percentage correct, of maximum 13 points
Knowledge – nutrition and health	Percentage correct, of maximum 16 points
Recognition of fruits and vegetables	Percentage correctly named, of 20
Recognition of fruits	Percentage correctly named, of 5
Recognition of vegetables – overall	Percentage correctly named, of 15
Recognition of vegetables – global	Percentage correctly named, of 6
Recognition of vegetables – TAV	Percentage correctly named, of 9
Familiarity with taste of fruits and vegetables	Percentage reported to be known, of 20
Familiarity with taste of fruits	Percentage reported to be known, of 5
Familiarity with taste of vegetables – overall	Percentage reported to be known, of 15
Familiarity with taste of vegetables – global	Percentage reported to be known, of 6
Familiarity with taste of vegetables – TAV	Percentage reported to be known, of 9
Liking taste of fruits and vegetables	Percentage reported to like, of 20
Liking taste of fruits	Percentage reported to like, of 5
Liking taste of vegetables – overall	Percentage reported to like, of 15
Liking taste of vegetables – global	Percentage reported to like, of 6
Liking taste of vegetables – TAV	Percentage reported to like, of 9
Individual dietary diversity score	Number of food groups consumed on previous day, 0-9
Intake of dark green leafy vegetables	Consumption on previous day (yes / no)
Intake of other vitamin A-rich fruits or vegetables	Consumption on previous day (yes / no)
Intake of other fruits or vegetables	Consumption on previous day (yes / no)
Intake of vegetables – any	Consumption on previous day (yes / no)

The impact of the intervention was estimated as: $Y_{it} = \alpha + \beta_1 D_i T_t + \beta_2 D_i + \beta_3 T_t + \varepsilon_{it}$
Where:

- $\mathbf{Y_{it}}$ are the outcomes of interest for student **i** at time **t**;
- **α** is the constant term;
- **β** is the coefficient that gives the DiD estimate of the parameter of interest;
- **D** is the dichotomous dummy variable that indicates beneficiary (treatment, D=1) or non-beneficiary (control, D=0) status;
- **T** is the indicates the survey round (T=0 for the baseline, and T=1 for the endline);
- **ε** is the error term.

4. Results and discussion

Sample characteristics

Information provided by teachers at the baseline indicated participating schools had an average of 540 students in total, with an average of 41 students per class, and 19 teachers and 3 non-academic staff per school (Table 2). All schools had a school garden at the time of the baseline survey, as a precondition for inclusion in the study; but by the time of the endline survey, one school garden in the non-intervention group was not functional. Based on teachers' estimates, school gardens ranged in size from 100 m^2 to 20,000 m^2, with a median size of 3,500 m^2.

Table 2. Characteristics of participating schools in Eswatini

Variable	Pooled	Treatment arm		
		Control	TAVI-2‡	TAVI-3‡
Number of children in the school	540 (272)	484 (254)	526 (234)	611 (338)
Number of classes in the school	14 (5)	13 (5)	15 (5)	15 (6)
Number of children per class	37 (9)	38 (10)	35 (6)	39 (11)
Number of teachers in the school	19 (8)	17 (7)	19 (7)	21 (9)
Number of non-teaching / non-academic staff	3 (2)	3 (2)	3 (1)	3 (2)
Number of schools	*24*	*8*	*8*	*8*

Notes: Mean values are shown with standard deviation in parentheses. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; ‡ Differences between the specific intervention and control tested using *t*-tests.

Table 3 presents a summary of characteristics of children who participated in the study. A total of 1,105 school children completed surveys at the baseline, and 989 at the endline. An approximately even proportion of male and female children were interviewed, with no significant differences between intervention categories. The mean age of children was 12.2 years at the baseline and 13.1 years at endline. Around four in five children (82% at baseline and 81% at endline) reported walking to school, with the remainder travelling by public bus. A significantly higher percentage of children walked to school in both of the intervention category schools, compared to non-intervention schools, at the baseline; but this difference was non-significant at endline. In the baseline survey, 82% of children reported having eaten before coming to school that day. In the endline survey, this had dropped significantly to 74% (p = 0.002). Accounting for children's age and gender and clustering at the school level, a significantly lower reduction over time was observed among children in TAVI-3 schools, compared to non-intervention schools (p = 0.044).

Table 3. Characteristics of sampled school children, at the baseline and endline

Variable	Pooled	Treatment arm		
		Control	TAVI-2‡	TAVI-3‡
Baseline				
Male (%)	50.5 (50.0)	50.3 (50.1)	48.7 (50.0)	52.6 (50.0)
Age (years)	12.2 (1.6)	12.4 (1.7)	12.3 (1.4)	12.1 (1.7)**
Walk to school (%)	81.9 (38.5)	77.4 (41.9)	88.7 (31.7)***	79.1 (40.7) ***
Ate before school on day of survey (%)	81.8 (38.6)	83.6 (37.1)	82.9 (37.7)	78.9 (40.8)*
Observations	*1105*	*354*	*388*	*363*
Endline				
Male (%)	49.8 (50.0)	50.0 (50.1)	48.1 (50.0)	51.6 (50.1)
Age (years)	13.1 (1.3)	13.3 (1.4)	13.1 (1.2)**	12.9 (1.4) ***
Walk to school (%)	80.5 (39.7)	77.5 (41.8)	86.5 (34.3)	77.0 (42.1)
Ate before school on day of survey (%)	74.4 (43.7)	70.3 (45.8)	76.1 (42.7)	76.7 (42.3)*
Observations	*989*	*320*	*347*	*322*

Notes: Mean values are shown with standard deviation in parentheses. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; ‡ Differences between the specific intervention and control tested using *t*-tests. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Children's involvement in school garden activities

Overall, three-quarters (75%) of children reported working in school gardens at the time of the baseline survey. Their level and type of involvement in garden activities differed significantly between intervention categories at the baseline (Table 4), with higher levels of involvement in TAVI-2 schools and lower involvement in TAVI-3 schools, compared the control group. At the endline, 96% of children were working in the school gardens. This reflects an expected expansion of children's participation in different gardening tasks, from Grade 6 to Grade 7. At the endline, a significantly higher proportion of children in TAVI schools were involved in gardens, compared to non-TAVI schools (99% and 90%, respectively). Children in TAVI schools also worked in gardens significantly more frequently, compared to those in non-TAVI schools (an average of 7.4 times per week and 4.9 times per week, respectively).

When looking at changes over time in intervention and control schools, we see mixed results (Table 5 and Figure 3). With high baseline levels of garden participation in TAVI-2 schools, the magnitude of the increase to endline was lower than in the control schools, where baseline participation was lower (6.6 percentage point (pp) increase and 26.6 pp increase, respectively). For many measures, we see a higher percentage point increase over time in TAVI-3 schools compared to control schools – however, after accounting for clustering at the school level, as well as children's age and gender, many of these differences were not statistically significant. We do observe a significantly greater increase over time in children's involvement in fertilizer application and other garden management practices in TAVI-3 schools, compared to control schools, and in the frequency of working in school gardens, which rose from an average of 2.5 to 7.5 times per week in TAVI-3 schools, compared to an increase from 2.5 to 4.9 times per week in control schools.

Table 4. Overview of children's involvement in school gardens, at the baseline and endline

Variable	Pooled	Treatment arm			
		Control	TAVI-2‡	TAVI-3‡	All TAVI
Baseline					
Work in school garden (%)	74.6	63.4	92.2 ***	66.8	79.9 ***
	(43.6)	(48.2)	(26.9)	(47.2)	(40.1)
Activities in the school garden (%)					
Soil preparation	60.5	53.7	69.5 ***	57.5	63.7 ***
	(48.9)	(49.9)	(46.1)	(49.5)	(48.1)
Making plots or planting beds	56.0	55.0	68.3 ***	43.8 ***	56.5
	(49.7)	(49.8)	(46.6)	(49.7)	(49.6)
Sowing or transplanting	41.4	45.0	45.2	33.5 ***	39.6
	(49.3)	(49.8)	(49.8)	(47.3)	(48.9)
Fertilizer application	34.3	41.2	41.2	19.9 ***	30.9 ***
	(47.5)	(49.3)	(49.3)	(40.0)	(46.3)
Other garden management practices	47.4	48.4	57.3 **	35.7 ***	46.9
	(50.0)	(50.1)	(49.5)	(48.0)	(49.9)
Times per week worked in the school garden	3.1	2.5	4.3 ***	2.5	3.4 ***
	(3.0)	(2.7)	(3.2)	(2.7)	(3.1)
Endline					
Work in school garden (%)	95.7	90.0	98.8 ***	98.1 ***	98.5 ***
	(20.2)	(30.0)	(10.7)	(13.6)	(12.2)
Activities in the school garden (%)					
Soil preparation	86.2	81.9	91.1 ***	85.4	88.3 ***
	(34.5)	(38.6)	(28.6)	(35.4)	(32.1)
Making plots or planting beds	83.8	76.9	87.9 ***	86.3 ***	87.1 ***
	(36.9)	(42.2)	(32.7)	(34.4)	(33.5)
Sowing or transplanting	73.4	66.2	76.0 ***	77.6 ***	76.8 ***
	(44.2)	(47.4)	(42.8)	(41.7)	(42.2)
Fertilizer application	80.2	73.4	86.5 ***	80.1 **	83.4 ***
	(39.9)	(44.2)	(34.3)	(40.0)	(37.2)
Other garden management practices	78.9	72.8	79.8 ***	83.9 ***	81.8 ***
	(40.8)	(44.6)	(40.2)	(36.9)	(38.6)
Times per week worked in the school garden	6.6	4.9	7.4 ***	7.5 ***	7.4 ***
	(3.7)	(3.4)	(3.5)	(3.6)	(3.5)
Observations	*989*	*320*	*347*	*322*	*669*

Notes: Mean values are shown with standard deviation in parentheses. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions. ‡ Differences between the specific intervention and control tested using *t*-tests at the baseline and endline. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

Table 5. Difference-in-difference estimation for children's involvement in school garden activities

	TAVI-2				TAVI-3				All TAVI			
Work in school garden (%)		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	92.2	98.8	6.6	Intervention	66.8	98.1	31.3	Intervention	79.9	98.5	18.6
	Control	63.4	90.0	26.6	Control	63.4	90.0	26.6	Control	63.4	90.0	26.6
	Difference	28.8	8.8	**-20.0**	*Difference*	3.4	8.1	**4.7**	*Difference*	16.5	8.5	**-8.0**
Times per week worked in school garden	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	4.3	7.4	3.1	Intervention	2.5	7.5	5.0	Intervention	3.4	7.4	4.0
	Control	2.5	4.9	2.4	Control	2.5	4.9	2.4	Control	2.5	4.9	2.4
	Difference	1.8	2.5	**0.7**	*Difference*	0.0	2.6	**2.6 ****	*Difference*	0.9	2.5	**1.6**
Activities in school garden (%)												
a. Soil preparation	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	69.5	91.1	21.6	Intervention	57.5	85.4	27.9	Intervention	63.7	88.3	24.6
	Control	53.7	81.9	28.2	Control	53.7	81.9	28.2	Control	53.7	81.9	28.2
	Difference	15.8	9.2	**-6.6**	*Difference*	3.8	3.5	**-0.3**	*Difference*	10.0	6.4	**-3.6**
b. Making plots or planting beds	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	68.3	87.9	19.6	Intervention	43.8	86.3	42.5	Intervention	56.5	87.1	30.6
	Control	55.0	76.9	21.9	Control	55.0	76.9	21.9	Control	55.0	76.9	21.9
	Difference	13.3	11.0	**-2.3**	*Difference*	-11.2	9.4	**20.6**	*Difference*	1.5	10.2	**8.7**
c. Sowing or transplanting	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	45.2	76.0	30.8	Intervention	33.5	77.6	44.1	Intervention	39.6	76.8	37.2
	Control	45.0	66.2	21.2	Control	45.0	66.2	21.2	Control	45.0	66.2	21.2
	Difference	0.2	9.8	**9.6**	*Difference*	-11.5	11.4	**22.9**	*Difference*	-5.4	10.6	**16.0**
d. Fertilizer application	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	41.2	86.5	45.3	Intervention	19.9	80.1	60.2	Intervention	30.9	83.4	52.5
	Control	41.2	73.4	32.2	Control	41.2	73.4	32.2	Control	41.2	73.4	32.2
	Difference	0.0	13.1	**13.1**	*Difference*	-21.3	6.7	**28.0 ****	*Difference*	-10.3	10.0	**20.3 ***
e. Other garden management practices	TAVI-2				TAVI-3				All TAVI			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	57.3	78.9	21.6	Intervention	35.7	83.9	48.2	Intervention	46.9	81.8	34.9
	Control	48.4	72.8	24.4	Control	48.4	72.8	24.4	Control	48.4	72.8	24.4
	Difference	8.9	6.1	**-2.8**	*Difference*	-12.7	11.1	**23.8 ***	*Difference*	-1.5	9.0	**10.5**

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference-in-difference tests include children's age and gender as covariates, and account for clustering at the school level. Significant differences denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

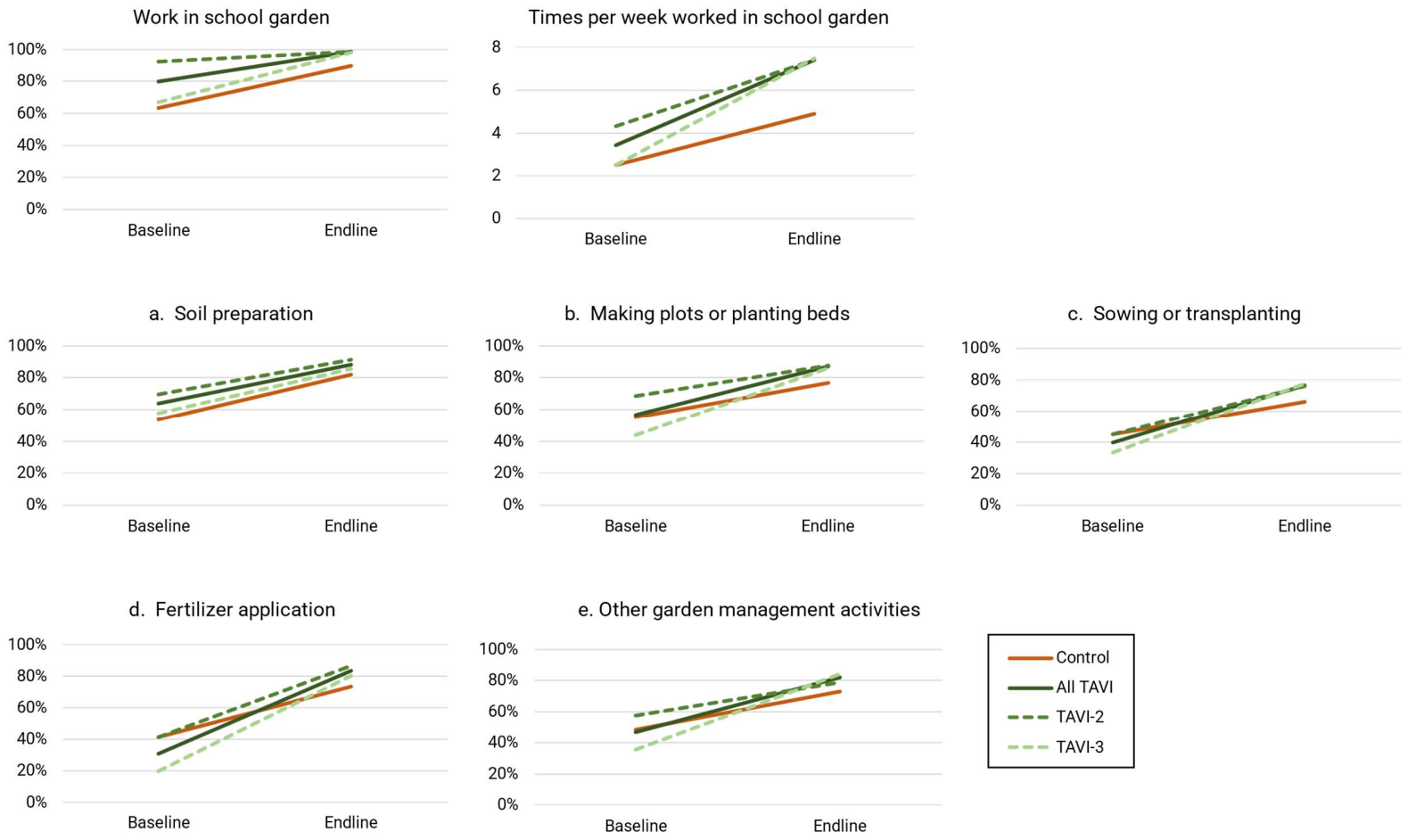

Figure 3. Children's involvement in school gardens, overall and by specific activity

Vegetable production in school gardens

There were no traditional African vegetables grown in participating schools at the time of the baseline survey. Vegetables grown in intervention schools (TAVI-2 and TAVI-3 combined, *n* = 16) and control schools (*n* = 8) are shown in Figure 4, based on information provided by teachers primarily responsible for school gardens. Spinach was the most common vegetable at the baseline, grown in half of all schools (50% of control schools, 56% of intervention schools). Other common vegetables included lettuce, onion, carrot, tomato and beetroot.

In the endline survey, teachers reported five traditional African vegetables as having been grown in intervention schools. The most common of these was Ethiopian mustard (reported in 38% TAVI schools), followed by okra and amaranth (each grown by 25%), cowpea (13%) and African nightshade (6%). A shift away from global vegetables was seen in these schools, with a majority of items grown by fewer intervention schools at endline compared to baseline. No traditional African vegetables were reported to be grown in the control schools in the endline survey.

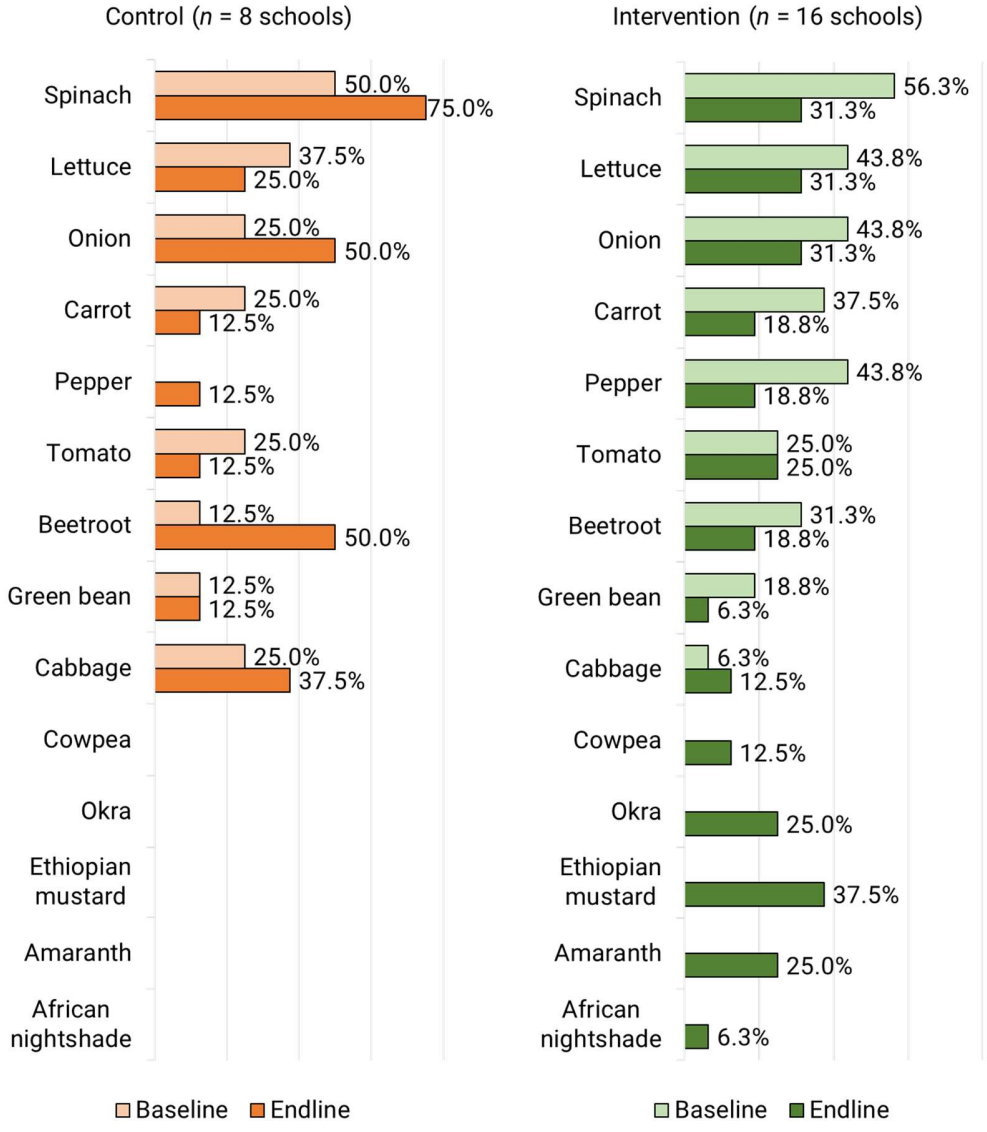

Figure 4. Vegetables produced in school gardens, at the baseline and endline

Vegetable supply to school canteens

The amounts and dates of vegetables supplied by local farmers to school canteens were recorded at the school level. Farmers received payment based on the documented quantities of vegetables supplied. Vegetables were predominantly traditional African vegetables (amaranth, African nightshade leaves and fruit, African eggplant, Ethiopian mustard, cowpea leaves, jute mallow, okra, and pumpkin leaves), but also included pumpkin and tomatoes. For leafy vegetables, which formed the bulk of vegetables supplied, Figure 5 presents the monthly quantities and frequency of supply to schools between the start of October 2022 and end of October 2023.

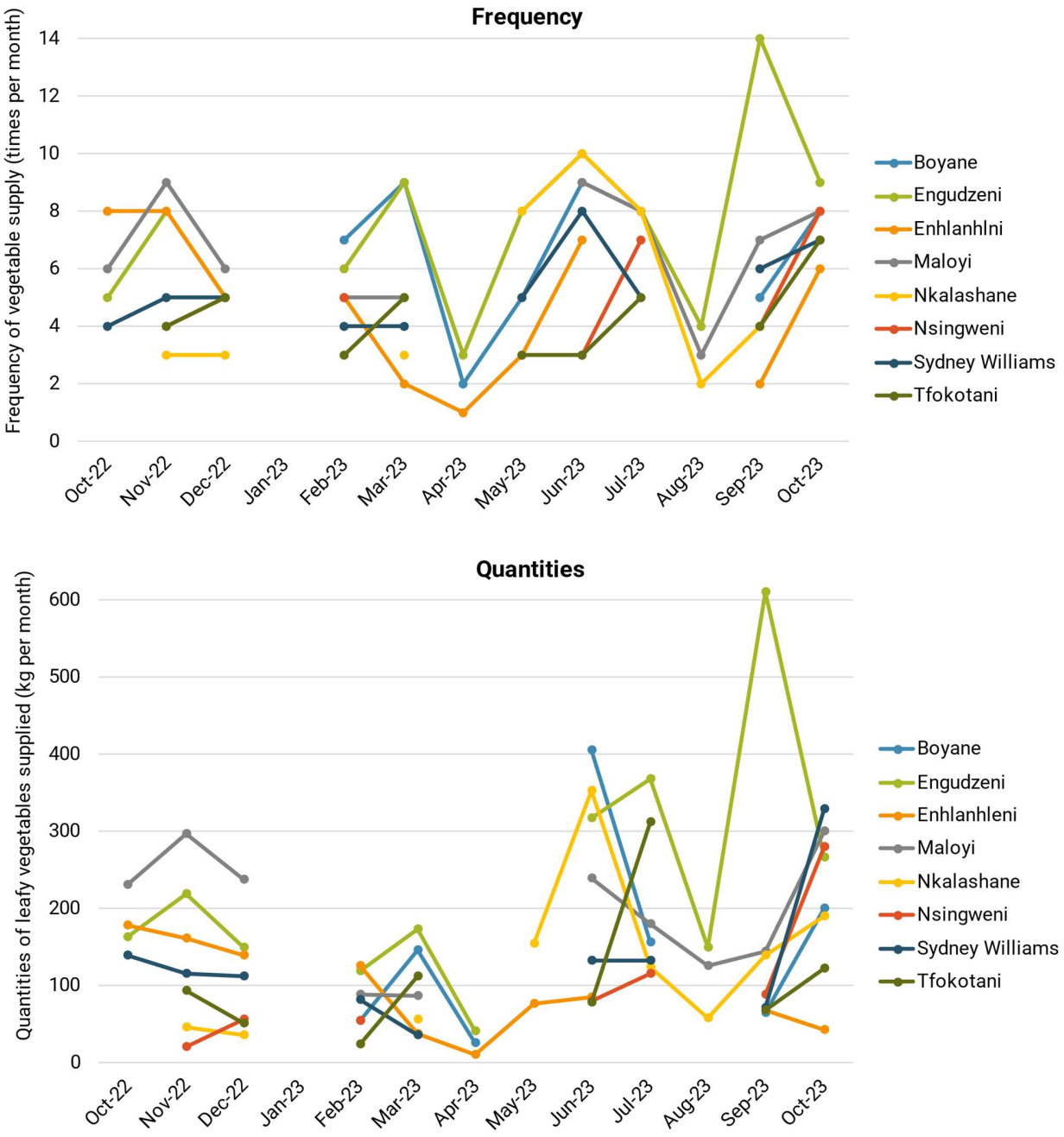

Figure 5. Frequency (above) and quantities (below) of leafy traditional African vegetables supplied to TAVI-3 schools by local farmers.

Accounting for school holidays during this period, Figure 6 shows the quantity and frequency of leafy vegetables supplied to schools as a weekly average. The average weekly quantity ranged from 15 kg to 55 kg between schools, with an overall mean weekly supply of 27 kg. The average frequency of vegetables being supplied ranged from 0.8 to 2.1 times per week between schools, with an overall mean frequency of 1.3 times per week during the recording period.

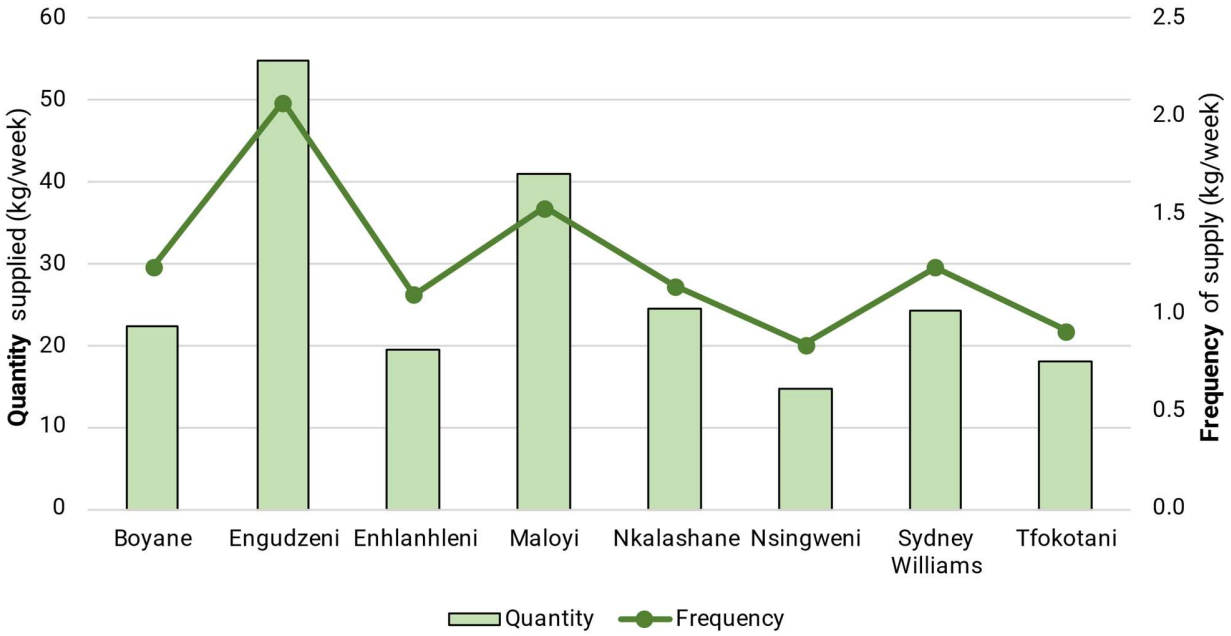

Figure 6. Average quantity and frequency of leafy traditional African vegetables supplied to TAVI-3 schools per week over a 13-month period of recording.

Key outcome indicators

Knowledge about gardening and nutrition

Children's knowledge was measured through a series of multiple-choice and free-response questions. Questions on gardening knowledge covered the requirements of a seedbed, process of transplanting seedlings, and requirements for growing vegetables. A separate module focused specifically on compost, including the materials needed and steps to prepare and maintain a compost heap. A third set of questions on nutrition and health covered the functions of nutrients within the body, and dietary sources of specific nutrients. Knowledge scores were assigned for each area. Analyses were conducted based on the percentage of the maximum number of points scored.

Knowledge about compost was notably low at the baseline, with an average score of 5%, and was significantly lower in TAVI schools than control schools (4% and 6%, respectively; Table 6). Knowledge of gardening practices and nutrition was also significantly lower in TAVI-2 schools, compared to control schools (18% and 21%, respectively, for gardening; 60% and 62%, respectively, for nutrition; Table 6). At the endline, significantly higher gardening and compost knowledge scores were recorded in TAVI schools, compared to control schools.

Accounting for clustering at the school level, and children's age and gender, we observe a significantly greater improvement in compost-related knowledge over time in TAVI schools, compared to non-TAVI schools (21.7 pp increase and 10.8 pp increase, respectively; see Table 7). Nutrition knowledge was substantially higher than gardening and compost knowledge at the baseline, with an average score of 61%. This rose to 67% by the endline survey, but no significant variation was seen between intervention and control schools.

Table 6. Overview of children's knowledge of gardening and nutrition, at the baseline and endline

Variable	Pooled	Treatment arm			
		Control	TAVI-2‡	TAVI-3‡	TAVI-2&3
Baseline					
Knowledge (%)					
Gardening practices	20.8	21.4	18.4 **	22.7	20.5
	(19.2)	(19.2)	(17.7)	(20.4)	(19.2)
Compost	4.5	6.0	5.8	1.5 ***	3.7 ***
	(13.2)	(13.6)	(16.5)	(6.5)	(12.9)
Nutrition and health	61.3	62.3	59.6 ***	62.3	60.9
	(12.9)	(13.0)	(12.8)	(12.8)	(12.9)
Endline					
Knowledge (%)					
Gardening practices	31.6	29.1	31.5 *	34.3 ***	32.8 ***
	(18.0)	(19.8)	(17.3)	(16.6)	(17.0)
Compost	22.6	16.8	30.6 ***	19.7 *	25.4 ***
	(22.1)	(16.8)	(23.8)	(22.3)	(23.7)
Nutrition and health	67.4	67.7	67.3	67.3	67.3
	(13.4)	(13.1)	(13.0)	(14.1)	(13.6)
Observations	*989*	*320*	*347*	*322*	*669*

Notes: Mean values are shown with standard deviation in parentheses. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions. ‡ Differences between the specific intervention and control tested using *t*-tests at the baseline and endline. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

Table 7. Difference-in-difference estimation for children's knowledge of gardening and nutrition

Knowledge questions (% correct)												
a. Gardening practices (of 14)	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	18.4	31.5	13.1	Intervention	22.7	34.3	11.6	Intervention	20.5	32.8	12.3
	Control	21.4	29.1	7.7	Control	21.4	29.1	7.7	Control	21.4	29.1	7.7
	Difference	-3.0	2.4	**5.4**	*Difference*	1.3	5.2	**3.9**	*Difference*	-0.9	3.7	**4.6**
b. Compost (of 13)	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	5.8	30.6	24.8	Intervention	1.5	19.7	18.2	Intervention	3.7	25.4	21.7
	Control	6.0	16.8	10.8	Control	6.0	16.8	10.8	Control	6.0	16.8	10.8
	Difference	-0.2	13.8	**14.0 ****	*Difference*	-4.5	2.9	**7.4**	*Difference*	-2.3	8.6	**10.9 ****
c. Nutrition and health (of 16)	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	59.6	67.3	7.7	Intervention	62.3	67.3	5.0	Intervention	60.9	67.3	6.4
	Control	62.3	67.7	5.4	Control	62.3	67.7	5.4	Control	62.3	67.7	5.4
	Difference	-2.7	-0.4	**2.3**	*Difference*	0.0	-0.4	**-0.4**	*Difference*	-1.4	-0.4	**1.0**

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference-in-difference tests include children's age and gender as covariates, and account for clustering at the school level. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

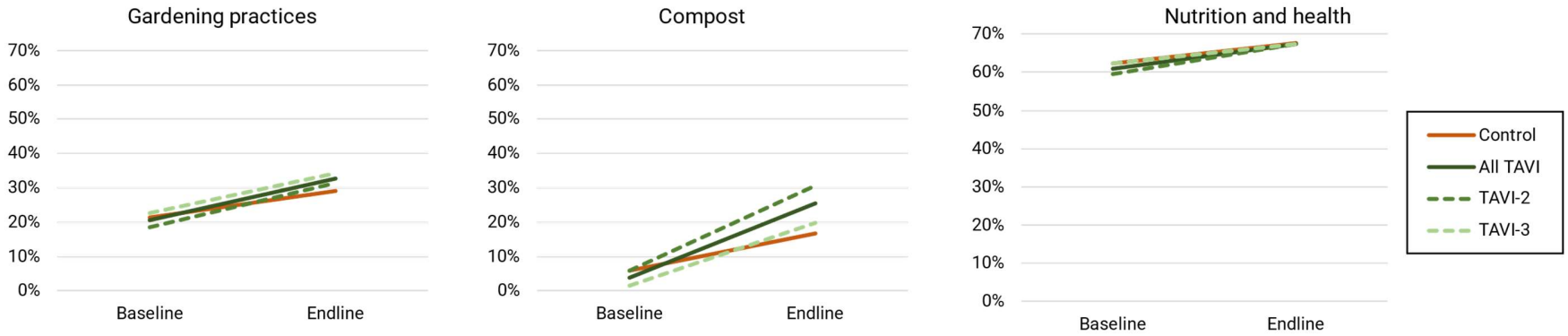

Figure 7. Children's knowledge of agriculture, nutrition and health, at the baseline and endline

Awareness of fruits and vegetables

Children's awareness of fruits and vegetables was measured in two ways: (1) *recognition*, based on correct naming of colored photographs (in English or SiSwati), and (2) *familiarity*, based on self-reporting of having eaten pictured items. Awareness was assessed for a total of 20 items: five fruits and 15 vegetables. Findings for vegetables have been disaggregated into global vegetables (tomato, carrot, onion, cabbage, pepper and spinach) and traditional African vegetables (amaranth, African nightshade, cowpea leaves, Ethiopian mustard, jute mallow, pumpkin leaves, mungbean, okra and African eggplant).

Much higher levels of both recognition and familiarity were observed for global vegetables and fruits, compared to traditional African vegetables. There were no significant differences in recognition or familiarity between intervention and control schools at the baseline (Table 8). We observe a small to moderate decrease in both the average percentage of traditional African vegetables recognized and the average percentage for which children report being familiar with the taste, between the baseline and endline surveys. This change largely reflects the markedly lower numbers of children correctly identifying amaranth and Ethiopian mustard in the endline survey – both of which were among vegetables for which photographs were updated in an effort to improve their clarity.

Despite this overall downward trend, we identify a statistically significant widening of the gap in recognition of traditional vegetables between TAVI and control schools. A 5.7 percentage point difference is seen in the baseline-endline change in recognition, with better results among children in TAVI schools (Table 9). Interestingly, baseline data indicates more children were familiar with the taste of pictured traditional African vegetables than were able to correctly identify items by name (46% and 36%, respectively). This may reflect the reality of children knowing the taste, but not the name, of certain vegetables, or an inaccurate self-reporting of familiarity.

At endline, significantly higher awareness of traditional vegetables is observed in TAVI schools compared to control schools (32% and 28%, respectively, for recognition; 32% and 27%, respectively, for familiarity with taste; Table 9). However, accounting for clustering, children's age and gender, and changes over time, no significant impact of the intervention on familiarity was detected (Table 9).

Preferences for fruits and vegetables

For the same set of 20 fruits and vegetables, children who reported having tasted pictured items were asked to give a preference ranking using a four-point Likert scale. Children reporting 'liking' or 'liking a lot' items have been grouped together, and an overview of the average percentage of children liking vegetables is shown in Table 8. As for recognition and familiarity, a general downward trend was seen between the baseline and endline surveys. This may reflect more defined taste preferences, or greater confidence to express negative taste preferences, among children over time. One notable finding is that children in TAVI-3 schools, to which champion farmers supplied vegetables for use in school meals, had a smaller decline in their liking of traditional African vegetables over time, compared to children in control schools.

Table 8. Overview of children's awareness and liking of fruits and vegetable, at the baseline and endline

Variable	Pooled	Treatment arm			
		Control	TAVI-2‡	TAVI-3‡	TAVI-2&3
Baseline					
Recognition of photographs (%)					
Fruits and vegetables (of 20)	67.2	67.3	66.9	67.4	67.1
Vegetables (of 15)	57.9	58.1	57.6	58.2	57.9
Global vegetables (of 6)	91.1	90.2	91.7	91.3	91.5
Traditional African vegetables (of 9)	35.8	36.8	34.8	36.1	35.4
Fruits (of 5)	94.9	94.6	94.8	95.2	95.0
Familiarity with taste (%)					
Fruits and vegetables (of 20)	72.7	72.8	71.9	73.5	72.7
Vegetables (of 15)	64.9	65.2	63.7	65.7	64.7
Global vegetables (of 6)	93.4	93.0	93.5	93.6	93.6
Traditional African vegetables (of 9)	45.8	46.7	43.9 *	47.1	45.4
Fruits (of 5)	96.3	95.8	96.5	96.7	96.6
Liking taste (%)					
Fruits and vegetables (of 20)	57.9	59.3	57.4*	57.2 *	57.3 **
Vegetables (of 15)	46.8	48.4	46.2 *	45.8 *	46.0 **
Global vegetables (of 6)	70.4	72.6	71.0	67.8 **	69.4 *
Traditional African vegetables (of 9)	31.0	32.3	29.7 **	31.1	30.4
Fruits (of 5)	91.3	91.8	90.9	91.4	91.1
Endline					
Recognition of photographs (%)					
Fruits and vegetables (of 20)	65.6	64.8	65.6	66.3 *	65.9
Vegetables (of 15)	56.0	54.8	56.3 *	57.0 **	56.7 **
Global vegetables (of 6)	93.6	94.8	93.6	92.5 **	93.1 *
Traditional African vegetables (of 9)	31.0	28.1	31.5 ***	33.3 ***	32.4 ***
Fruits (of 5)	94.1	94.9	93.5	94.1	93.8
Familiarity with taste (%)					
Fruits and vegetables (of 20)	64.7	63.7	65.1 *	65.4 **	65.2 **
Vegetables (of 15)	55.2	53.7	56.0 ***	56.0 **	56.0 ***
Global vegetables (of 6)	92.3	93.1	92.4	91.4	91.9
Traditional African vegetables (of 9)	30.6	27.4	31.8 ***	32.4 ***	32.1 ***
Fruits (of 5)	93.2	93.9	92.3	93.5	92.9
Liking taste (%)					
Fruits and vegetables (of 20)	52.1	51.3	50.9	54.1 ***	52.4
Vegetables (of 15)	39.6	38.1	38.7	42.2 **	40.3 **
Global vegetables (of 6)	65.2	65.1	63.0	67.8	65.3
Traditional African vegetables (of 9)	22.6	20.2	22.4 *	25.1 ***	23.7 ***
Fruits (of 5)	89.3	90.6	87.8 *	89.8	88.7
Observations	*989*	*320*	*347*	*322*	*669*

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference between the specific intervention and control tested using t-test. Significant difference denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

Table 9. Difference-in-difference estimation for children's recognition of and familiarity with vegetables

Recognition of photographs (%)												
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
a. Vegetables	Intervention	57.6	56.3	-1.3	Intervention	58.2	57.0	-1.2	Intervention	57.9	56.7	-1.2
	Control	58.1	54.8	-3.3	Control	58.1	54.8	-3.3	Control	58.1	54.8	-3.3
	Difference	-0.5	1.5	**2.0**	*Difference*	0.1	2.2	**2.1**	*Difference*	-0.2	1.9	**2.1**
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
b. Global vegetables	Intervention	91.7	93.6	1.9	Intervention	91.3	92.5	1.2	Intervention	91.5	93.1	1.6
	Control	90.2	94.8	4.6	Control	90.2	94.8	4.6	Control	90.2	94.8	4.6
	Difference	1.5	-1.2	**-2.7**	*Difference*	1.1	-2.3	**-3.4**	*Difference*	1.3	-1.7	**-3.0**
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
c. Traditional African vegetables	Intervention	34.8	31.5	-3.3	Intervention	36.1	33.3	-2.8	Intervention	35.4	32.4	-3.0
	Control	36.8	28.1	-8.7	Control	36.8	28.1	-8.7	Control	36.8	28.1	-8.7
	Difference	-2.0	3.4	**5.4 ****	*Difference*	-0.7	5.2	**5.9 ***	*Difference*	-1.4	4.3	**5.7 ****
Familiarity with taste (%)												
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
a. Vegetables	Intervention	65.7	56.0	-9.7	Intervention	64.7	56.0	-8.7	Intervention	63.7	56.0	-7.7
	Control	65.2	53.7	-11.5	Control	65.2	53.7	-11.5	Control	65.2	53.7	-11.5
	Difference	0.5	2.3	**1.8**	*Difference*	-0.5	2.3	**2.8**	*Difference*	-1.5	2.3	**3.8**
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
b. Global vegetables	Intervention	93.6	91.4	-2.2	Intervention	93.6	91.9	-1.7	Intervention	93.5	92.4	-1.1
	Control	93.0	93.1	0.1	Control	93.0	93.1	0.1	Control	93.0	93.1	0.1
	Difference	0.6	-1.7	**-2.3**	*Difference*	0.6	-1.2	**-1.8**	*Difference*	0.5	-0.7	**-1.2**
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
c. Traditional African vegetables	Intervention	47.1	32.4	-14.7	Intervention	45.4	32.1	-13.3	Intervention	43.9	31.8	-12.1
	Control	46.7	27.4	-19.3	Control	46.7	27.4	-19.3	Control	46.7	27.4	-19.3
	Difference	0.4	5.0	**4.6**	*Difference*	-1.3	4.7	**6.0**	*Difference*	-2.8	4.4	**7.2 ***

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference-in-difference tests include children's age and gender as covariates, and account for clustering at the school level. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

Table 10. Difference-in-difference estimation for children enjoying vegetables

Liking taste (%)												
	TAVI-2				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
a. Vegetables	Intervention	46.2	38.7	-7.5	Intervention	45.8	42.2	-3.6	Intervention	46.0	40.3	-5.7
	Control	48.4	38.1	-10.3	Control	48.4	38.1	-10.3	Control	48.4	38.1	-10.3
	Difference	-2.2	0.6	**2.8**	*Difference*	-2.6	4.1	**6.7**	*Difference*	-2.4	2.2	**4.6**
	TAVI-2				**TAVI-3**				**All TAVI**			
b. Global vegetables		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	71.0	63.0	-8.0	Intervention	67.8	67.8	0.0	Intervention	69.4	65.3	-4.1
	Control	72.6	65.1	-7.5	Control	72.6	65.1	-7.5	Control	72.6	65.1	-7.5
	Difference	-1.6	-2.1	**-0.5**	*Difference*	-4.8	2.7	**7.5**	*Difference*	-3.2	0.2	**3.4**
	TAVI-2				**TAVI-3**				**All TAVI**			
c. Traditional African vegetables		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	29.7	22.4	-7.3	Intervention	31.1	25.1	-6.0	Intervention	30.4	23.7	-6.7
	Control	32.3	20.2	-12.1	Control	32.3	20.2	-12.1	Control	32.3	20.2	-12.1
	Difference	-2.6	2.2	**4.8**	*Difference*	-1.2	4.9	**6.1 ****	*Difference*	-1.9	3.5	**5.4**

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference-in-difference tests include children's age and gender as covariates, and account for clustering at the school level. Significant differences are denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes a statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

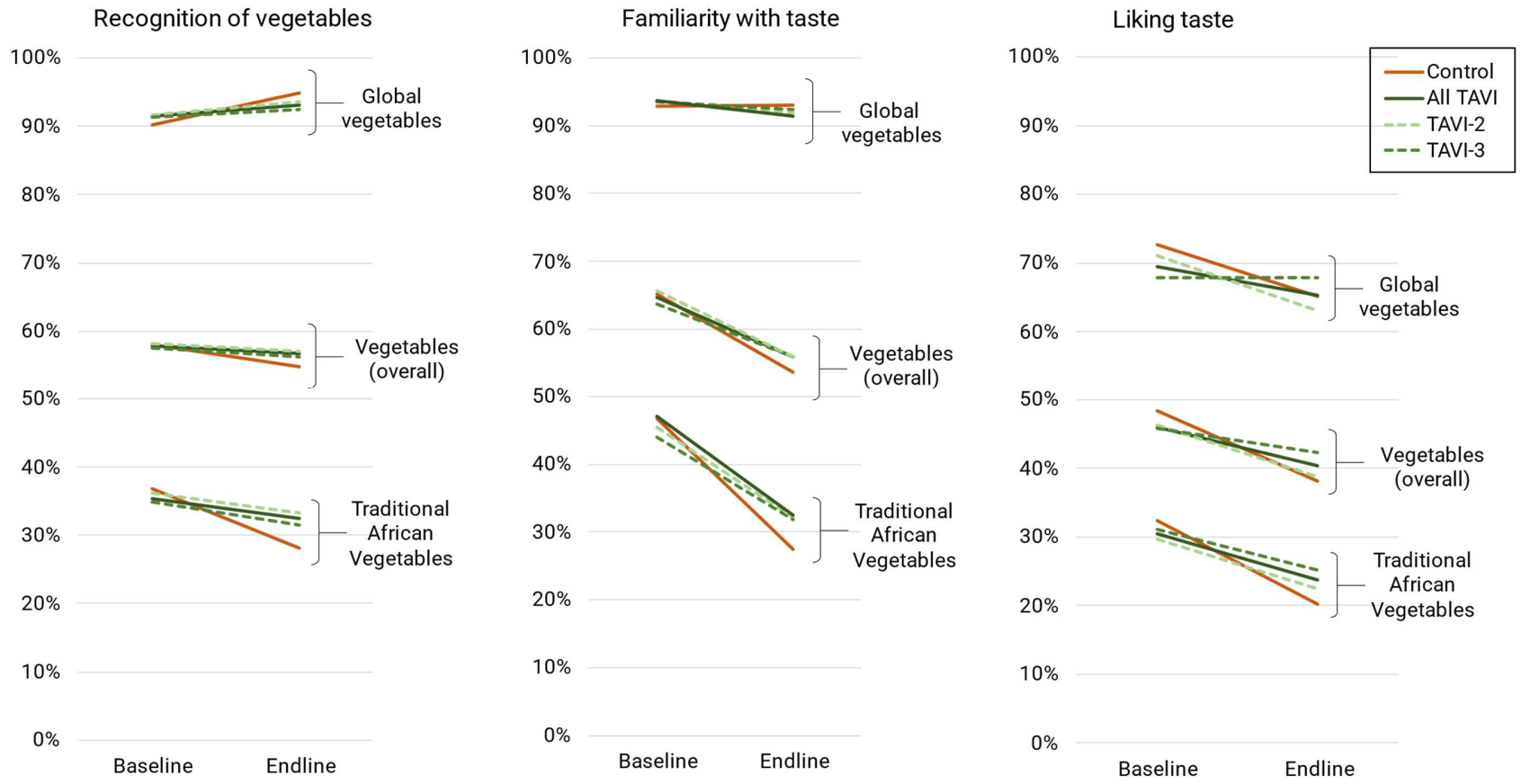

Figure 8. Children's recognition, familiarity and liking of vegetables, at the baseline and endline

Consumption of fruits and vegetables

Children's diets were assessed based on self-reported intake for the previous day, with free-listing of items consumed at school, at home or outside the home. The timing of data collection was designed to avoid recording of food consumed on weekends. Challenges were encountered in the baseline data, where some food items were recorded in general terms (e.g. 'fruit', 'sandwich', 'chicken stew'). Additional guidance was given during the endline data collection to record specific items, and to list all ingredients of mixed dishes. The Individual Dietary Diversity Score (IDDS), a measure of the number of different food groups consumed in a 24-hour period (of a maximum of 9 groups), was used as a simple measure of children's overall dietary quality.

An average score of 3.5 was reported in the overall sample at the baseline, and an average score of 4.4 at endline. This increase is likely to reflect variation in effectiveness of recording in the two surveys, with more specific and detailed listing of food items and ingredients in the endline. In looking at differences over time, however, we identify statistically significant differences in the extent of this increase between intervention groups. The average IDDS for children in TAVI-3 schools increased by 1.2 between baseline and endline, compared to an increase of 0.6 in control schools (Table 11). Of the three IDDS food groups which include vegetables, we see a significantly higher baseline-endline change in the percentage of children consuming dark green leafy vegetables in TAVI-3 schools, compared to control schools (32.0 pp increase and 7.5 pp increase, respectively).

Figure 9 shows the percentage of children consuming one or more vegetables on the day prior to data collection. At the baseline, the percentage reporting consumption of at least one traditional African vegetable is shown to be low and very similar between intervention groups. At the endline, we observe a much more substantial increase (32.0 pp) among children in TAVI-3 schools – which were assigned to receive vegetables from local champion farmers – than those in TAVI-2 or control schools (6.0 and 8.8 pp increases, respectively; Table 11); although the difference is not statistically significant (p = 0.058).

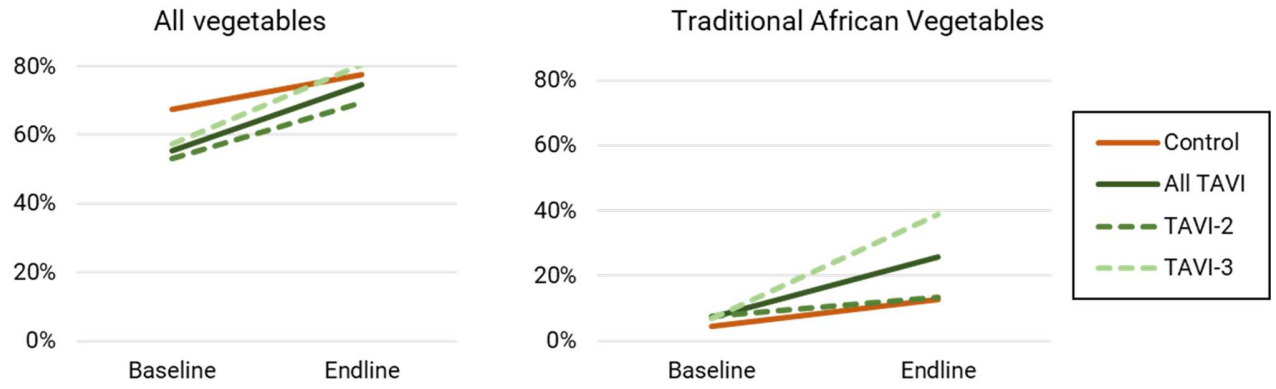

Figure 9. Children's consumption of vegetables on the day prior to the survey, at the baseline and endline.

Table 11. Difference-in-difference estimation for children's dietary intake, based on self-recording of diets

Individual Dietary Diversity Score (IDDS)	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	3.47	4.28	0.81	Intervention	3.53	4.69	1.16	Intervention	3.49	4.48	0.99
	Control	3.63	4.21	0.58	Control	3.63	4.21	0.58	Control	3.63	4.21	0.58
	Difference	-0.16	0.07	**0.23 ***	*Difference*	-0.1	0.48	**0.58 ****	*Difference*	-0.14	0.27	**0.41 ****
Consumption of IDDS food groups (%)												
a. Dark green leafy vegetables	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	7.2	11.8	4.6	Intervention	6.2	38.2	32.0	Intervention	6.7	24.5	17.8
	Control	4.7	12.2	7.5	Control	4.7	12.2	7.5	Control	4.7	12.2	7.5
	Difference	2.5	-0.4	**-2.9**	*Difference*	1.5	26.0	**24.5 ****	*Difference*	2.0	12.3	**10.3**
b. Other vit A-rich vegetables	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	30.3	33.7	3.4	Intervention	33.5	26.4	-7.1	Intervention	31.8	30.2	-1.6
	Control	42.5	39.4	-3.1	Control	42.5	39.4	-3.1	Control	42.5	39.4	-3.1
	Difference	-12.2	-5.7	**6.5**	*Difference*	-9.0	-13.0	**-4.0**	*Difference*	-10.7	-9.2	**1.5**
c. Other fruits and vegetables	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	65.7	70.0	4.3	Intervention	62.7	78.9	16.2	Intervention	64.3	74.3	10.0
	Control	73.4	75.3	1.9	Control	73.4	75.3	1.9	Control	73.4	75.3	1.9
	Difference	-7.7	-5.3	**2.4**	*Difference*	-10.7	3.6	**14.3 ***	*Difference*	-9.1	-1.0	**8.1**
Consumption of vegetables (%)												
a. Any	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	53.3	69.5	16.2	Intervention	57.5	80.4	22.9	Intervention	55.3	74.7	19.4
	Control	67.5	77.5	10.0	Control	67.5	77.5	10.0	Control	67.5	77.5	10.0
	Difference	-14.2	-8.0	**6.2**	*Difference*	-10.0	2.9	**12.9 ***	*Difference*	-12.2	-2.8	**9.4**
b. Traditional African Vegetables	**TAVI-2**				**TAVI-3**				**All TAVI**			
		Before	After	*Difference*		Before	After	*Difference*		Before	After	*Difference*
	Intervention	7.5	13.5	6.0	Intervention	6.8	38.8	32.0	Intervention	7.2	25.7	18.5
	Control	4.7	12.8	8.1	Control	4.7	12.8	8.1	Control	4.7	12.8	8.1
	Difference	2.8	0.7	**-2.1**	*Difference*	2.1	26.0	**23.9 ***	*Difference*	2.5	12.9	**10.4**

Notes: Mean values are shown. Control = schools with no intervention (control); TAVI-2 = schools with two TAVI interventions; TAVI-3 = schools with three TAVI interventions; All TAVI = schools with two or three TAVI interventions; ‡ Difference-in-difference tests include children's age and gender as covariates, and account for clustering at school level. Significant differences denoted by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Shading denotes statistically significant ($p < 0.05$) increase or decrease between baseline and endline.

5. Conclusions and recommendations

This study has sought to evaluate the comparative advantage of an 'improved' school garden program, and a home-grown school feeding program, over existing school gardens in improving the knowledge, attitudes and diets of children in primary schools of Eswatini. Since all participating schools included a functional school garden, this evaluation considers the influence of additional activities supported through the Taiwan Africa Vegetable Initiative. These have included (i) provision of quality seeds (with a strong emphasis on traditional African vegetables) and capacity strengthening of teachers to establish and maintain school gardens; (ii) delivery of a 10-week curriculum on nutrition and gardening; and (iii) contracting local farmers to provide vegetables to schools for use in school meals, and supporting traditional vegetable production through provision of seeds and technical assistance. Findings presented in this report largely reflect analysis of data from questionnaires completed by 989 children, at the baseline and endline.

Vegetable production in school gardens
The TAVI program clearly increased the use of traditional African vegetables in school gardens. None of the schools grew any traditional vegetables at the baseline, and none of the control schools grew any at endline. Based on teachers' responses, five different traditional vegetables were reported to be grown in intervention schools at endline. This included Ethiopian mustard (in six of 16 schools), okra and amaranth (each in four schools), cowpea (in two schools) and African nightshade (in one school). The survey format, in which a focal teacher was asked to list crops grown in the school garden, may have underestimated the true breadth of items produced over the previous 12 months; however, it would be valuable to further explore barriers to producing and harvesting a greater number of the vegetables for which seeds were distributed.

Children's participation in school gardens
Participation in school gardens increased substantially in all schools over the twelve-month period of this study; but the amount by which children's frequency of working in school gardens increased was significantly higher in TAVI-3 schools, compared to control schools. Accounting for clustering at the school level, almost all other variation in measures of garden participation were not statistically significant.

Children's knowledge about gardening and nutrition
Children's knowledge about gardening practices was relatively low at the baseline. A modest improvement was seen in all schools over time, with no significant differences between control and intervention schools. Specific knowledge about compost, assessed in a separate module of questions, improved substantially from notably low baseline levels – with significantly greater improvement among TAVI schools compared to control schools. In contrast, nutrition knowledge was high across all schools at the baseline, and there was therefore less scope for improvement. Future use of the curriculum in this project would benefit from a review of the content and structure of teaching materials, as well as the capacity of teachers to use these materials effectively.

Children's awareness of fruits and vegetables
Children had much greater awareness of fruits and global vegetables than traditional African vegetables, based on their ability to correctly name items based on photographs and their self-reported familiarity with the taste of pictured items. An unexpected downward trend in levels of awareness was seen over time in all schools. Several images from the baseline questionnaire, perceived to have been poor representations of the items in question, were replaced in the endline questionnaire. Despite pre-testing, two of the revised images (for amaranth and Ethiopian mustard) were correctly identified by substantially fewer students in the endline survey. This has contributed to lower endline scores for both recognition and taste familiarity. In spite of this, we identify a significant finding of greater recognition of traditional African vegetables among students from TAVI schools, compared to control schools. A higher level of children reporting familiarity with the taste of traditional vegetables is observed, but not statistically significant.

Liking of fruits and vegetables

As for awareness, the proportion of children enjoying fruits was substantially higher, and global vegetables moderately higher, than for traditional African vegetables. Findings of a downward trend in children's reported preference for fruits and vegetables was also seen over time. Importantly, a more favorable baseline-endline change in preference ratings was seen in TAVI-3 schools – where canteens received vegetables from local farmers – compared to control schools. The complex array of psycho-social factors underpinning taste preferences have not been well-studied in sub-Saharan African contexts (Okagbare and Naidoo, 2020). There is scope for future research into how children's acceptance of vegetables may be modified by the timing of introduction and by repeated exposure, as well as by alternative methods of preparation and food combinations. In Eswatini, further insights could be gained through qualitative research with children and caregivers to understand drivers of food preferences; and future interventions could consider community-level actions, beyond the school setting.

Consumption of fruits and vegetables

It is notoriously challenging to assess diets in any population, but documenting the diets of children is particularly problematic. Children may lack the cognitive skills, writing skills, food knowledge and motivation to provide accurate records of foods consumed (Foster and Adamson, 2014). In this study, enhanced attention to instructing and supporting students' self-recording of dietary intake during the endline data collection is likely to have contributed to higher dietary diversity scores, compared to the baseline. We do, however, identify a significantly greater increase in dietary diversity over time for children in TAVI-3 schools, receiving vegetables from local farmers, than in control schools; alongside a significantly greater increase in reported intake of dark green leafy vegetables. Similar patterns were not seen in TAVI-2 schools.

In future studies, we identify the need to consider alternative approaches to document the contribution of vegetables to children's diets. Since impact is expected to be seen within the school setting, a focus on food access through school meals may be a suitable alternative or additional indicator. The use of well-designed charts to allow cooking staff or teachers to document foods served in school meals should be considered. By allowing contemporaneous recording and an increased frequency and duration of data capture (e.g. food records completed for five consecutive days, several times per year), this could mitigate the known limitations of single-day recall periods, and recall bias with retrospective data collection. This may also allow quantitative measures to be used, to assess changes in vegetable portion sizes and the frequency of serving vegetables.

Our findings do support the likelihood that a home-grown school feeding program can increase access to and consumption of vegetables through school meals, beyond any effects of produce available through school gardens. Further insights can be gained from monitoring data for this component of the intervention: to understand the quantity and frequency with which vegetables were provided to schools, and the specific vegetables provided. There is a need to explore business models and sustainable value chain development, to ensure enhanced livelihoods for smallholder producers and nutritional benefits for children can extend beyond the timeline of project funding.

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