NUTRITION AWARENESS AND UTILIZATION OF ORANGE FLESHED SWEETPOTATO

Effect of nutrition awareness on utilization of Orange Fleshed Sweetpotato among vulnerable populations in Kenya

Authors:

Chalmers K. Mulwa[1*], Simon Heck[1], Joyce Maru[1], Josephine Mwema[2], Hugo Campos[3]

[1] International Potato Center, Kenya

[2] World Food Program, Kenya

[3] Intenational Potato Center, Peru

Corresponding author:

Chalmers K. Mulwa
International Potato Center, Sub-Saharan (SSA) Africa Regional Office
Nairobi, Kenya
Email: C.Mulwa@cgiar.org

1. Introduction

Vitamin A deficiency (VAD) continues to afflict many segments of the world's population, most of these residing in Low- and Middle-Income Countries. It is estimated that VAD accounts for over 600,000 deaths each year globally for children under five years of age, and is also associated with severity of diarrhoea among children, and anaemia and night blindness among pregnant women (Hotz, Loechl, Lubowa, et al., 2012). Scaling-up the adoption and utilization of biofortified crops is seen by many as a sustainable way of fighting the twin problems of food and nutritional insecurity (Van Der Straeten et al., 2020). Yet while concerted efforts have led to the development of biofortified crops capable of fighting hidden hunger, utilization of these remain low, which calls for demand creation strategies as well as efficient delivery models, for enhanced biofortification at scale (Foley et al., 2021).

Orange fleshed sweetpotato (OFSP) has been shown to substantially improve Vitamin A intake among children below the age of five, and that of pregnant and lactating women (Girard et al., 2017; Hotz, Loechl, De Brauw, et al., 2012). The International Potato Center (CIP) and partners in Africa, Asia and Latin America have developed more than one hundred locally adapted OFSP varieties and have promoted their dissemination through integrated delivery models including seed system, agronomic, post-harvest and demand creation interventions (Low & Thiele, 2020) These efforts have resulted in the adoption of OFSP by more than six million smallholder farmers (Heck et al., 2020). Based on its proven nutrition efficacy and the effectiveness of delivery models, OFSP is increasingly being considered as a nutrition-sensitive technology in humanitarian programming in regions without prior history of sweetpotato cultivation and with scant awareness of vitamin A deficiency and mitigating strategies. In this context, it is important to understand the relative role of demand-side interventions, such as awareness creation, for the adoption and utilization of OFSP among target populations, and how these interventions might be best combined with initial supply-side interventions to kick-start sustained adoption. Several studies have pointed to the importance of nutrition awareness creation for the acceptance and active utilization of biofortified crops, including OFSP (Adekambi et al., 2020; Shikuku et al., 2019).

The International Potato Center (CIP) and the World Food Programme (WFP) have been conducting interventions in the arid and semi-arid (ASAL) regions of Kenya since mid-2020, in a bid to promote the utilization of OFSP in the region. The partnership aims to exploit individual institutional strengths, with the former being an agricultural research center of excellence while the latter is the world leading humanitarian organization with immense capacity to reach the most vulnerable, to achieve the mutual goals of combating food insecurity and malnutrition among society's most vulnerable groups. Several interventions are fronted through this CIP-WFP partnership, key among these being raising awareness of VAD and the potential of OFSP in increasing Vitamin A intake (hereafter referred to simply as "nutrition awareness"). This study aims to give early evidence on the effect of raising this nutrition awareness on utilization of OFSP, as a way to combat VAD in the region, through enhanced vitamin A intake.

The study builds on extant literature on the importance of exposure to technologies for successful adoption (Adekambi et al., 2020; Diagne & Demont, 2007; Simtowe et al., 2016) and uses an impact evaluation framework to understand the effect of interventions aimed at raising nutrition awareness on OFSP utilization, and the drivers of exposure to nutrition awareness. This is important in assessing whether ongoing interventions are achieving intended results, as well as in guiding design of future interventions for higher and inclusive impacts. While the interventions pursued through the partnership take different forms, the focus on nutrition awareness is premised on the assumption that this is an enabling condition towards OFSP utilization. It is also unreasonable to assume that other interventions would be pursued in isolation without nutrition awareness. In this paper, OSFP utilization is defined as the adoption and/or use of OFSP by both producing and non-producing households, who access OFSP roots through the market or food aid.

The study contribution is two-fold; by focusing on OFSP utilization, rather than adoption, the study allows for the analysis of both OFSP producing and non-producing households, thereby bringing forth the role of markets in OFSP utilization, which is particularly important in this case since a large section of the population in ASALs are pastoralists. Secondly, using well-known impact evaluation methods, the study offers early evidence on the importance of novel partnerships in achieving impacts at often hard to reach vulnerable population segments, for higher impacts of improved technologies such as the biofortified orange fleshed sweetpotato.

2. Background to CIP-WFP interventions in the study area

In Kenya, the prevalence of vitamin A deficiency and marginal vitamin A deficiency is 4.5% and 24.2% respectively. According to the Kenya Demographic and Health Survey of 2014, stunting rates in the country are at 26%, wasting at 4% and underweight at 11% for children below five years of age. This situation is dire in fragile areas like the arid and semi-arid lands (ASALs) in the northern and eastern parts the country, where access to food is greatly curtailed due to unfavorable production conditions and low accessibility. Dependency on humanitarian assistance has become critical for the survival of populations living in these areas.

More recently, humanitarian agencies including the World Food Programme (WFP) have started including OFSP in their humanitarian programming through partnering with institutions like the international potato center (CIP), with an initial dual focus on OFSP production by vulnerable households and utilization of OFSP puree for young child feeding at household level. The pursued interventions in this CIP-WFP partnership have adopted a systems approach with the goal of enhancing OFSP utilization at the household level. Production at the household level is supported through establishing seed supply chains; local farmers are trained as 'Decentralized Vine Multipliers' (DVMs) and are linked to national organizations such as the Kenya Plant Health Inspectorate Service (KEPHIS) and the Kenya Agricultural & Livestock Research Organization (KALRO) for accessing clean seed for multiplication. Producing households are then linked to these DVMs, creating a supply of affordable OFSP planting material at the local level, while public extension workers are also trained on OFSP production and good agricultural practices for onward training to producing households. On the demand-side, several interventions are supported that aim to raise nutrition awareness. Such interventions include training of traders involved in sweetpotato marketing on OFSP as a high value nutritional crop; trainer of trainer (ToT) models for training expectant and breastfeeding mothers through ante- and post- natal clinics. Expectant and breastfeeding mothers are also trained on, and provided with, the "Healthy Baby Toolkit (HBT), a CIP invention aimed at providing guidance to mothers on preparation of OFSP puree for supplementing young children's diets.

In this study we focus only on the demand-side interventions, as listed above, that are aimed at raising nutrition awareness. While other system-wide interventions like supporting sustainable seed distribution systems, linking producers to the market, and market support are important in enhancing OFSP utilization at scale, we view nutrition awareness as an important initial enabling condition for household utilization of OFSP. Interventions aimed at disentangling supply-side constraints can achieve more impacts in an environment where targeted households have nutrition awareness and therefore more receptive to OFSP. The study therefore focuses on nutrition awareness as a crucial initial intervention in introducing OFSP in a region with low exposure to the crop, and where nutrition information is scarce.

3. Conceptual framework and estimation strategy

3.1 Conceptualization

Our study's main objective is to understand how interventions aimed at raising nutrition awareness among populations living in ASAL regions of Kenya affect the utilization of OFSP among these populations, and the attribution of this to CIP-WFP interventions. To enhance utilization of OFSP in the study area, CIP-WFP interventions have adopted a market systems approach where biofortification goals are sought not only for producing households, but other value chain actors including traders and consumers. Based on this, our study departs from others that purely focus on the adoption of technology (see for example Adekambi et al., 2020; Diagne & Demont, 2007; Dimara & Skuras, 2003) to focus on utilization of OFSP, which is a composite variable of consumption by OFSP producing and non-producing (through market participation). While agro-pastoralism is predominant in these regions, a non-trivial number of households are full pastoralists, and the only way to achieve OFSP utilization at scale is through market purchases. Hence focusing not only on OFSP adoption by producing households but also utilization by non-producing households is more apt for our study.

Unlike studies addressing similar problem to ours (see for example Adekambi et al., 2020; Diagne & Demont, 2007; Simtowe et al., 2016), our definition of "awareness" goes beyond the mere knowledge of the existence of a technology; instead, we define awareness of OFSP as the knowledge of its existence, including the potential nutritional benefits as a biofortified technology that can combat Vitamin A deficiency (VAD). This definition is more befitting in our case given the interventions led by the CIP-WFP partnership in raising awareness about VAD in the study areas and promoting utilization of OFSP as a potential remedy. Further, while such studies treat awareness of technology as trivial and rather focus on what informs adoption decisions, we posit that this first initial stage of awareness is critical to utilization of OFSP, typical of relatively new technologies (Dimara & Skuras, 2003). Understanding drivers to nutrition awareness is therefore important in this study, which is valuable in informing ongoing efforts to out-scale OFSP utilization in the intervention areas.

There are several challenges in estimating the effect of nutrition awareness on OFSP utilization. First, targeted areas for the CIP-WFP interventions aimed at raising nutrition awareness may benefit from intervention design bias, ranging from perceived state of malnutrition, physical accessibility, spatial spread of change agents (for example, clinics for training pregnant women and young mothers on nutrition awareness), among other factors. This may result in some systemic differences between areas reached by nutrition awareness interventions and those that are not, resulting in only a subset of the targeted population being exposed to the treatment, a phenomenon otherwise known as non-exposure bias (Atanu et al., 1994; Diagne & Demont, 2007; Dimara & Skuras, 2003). Secondly, diffusion of nutrition awareness across population of interest may differ systematically given factors like individual attitudes towards risk, self-interest and health consciousness, as well as other binding constraints like education levels, social capital, and proximity to change agents, etc. This gives rise to a self-selection problem in analyzing treatment effects in studies using observational data (Gitonga et al., 2020; C.K Mulwa et al., 2021).

While randomization in well-designed experimental studies can overcome such challenges as described above, this is not possible in observational studies such as ours. The key challenge is the identification of a true counterfactual, in the presence of non-randomness, for consistent intervention impact estimation. Several approaches abound in the empirical literature for the estimation of treatment impacts in the presence of non-randomness in the treatment (Asfaw et al., 2018; Gitonga et al., 2020; Kassie et al., 2015; C.K Mulwa & Visser, 2020; Terza et al., 2008). In this study, we utilize the propensity score matching method with reweighting on the propensity score (Cerulli, 2014) to create a true counterfactual and estimate the effect of nutrition awareness on utilization of OFSP. One drawback of propensity score method is the failure to control for non-observables as identified above in our case i.e., risk attitudes, self-interest and health consciousness. We therefore further use the endogenous switching regression (ESR) model to improve on the robustness of our results. A detailed description of the empirical specification is described next.

3.2 Estimation strategy

Using a counterfactual outcome framework (Wooldridge, 2002 Chapter 18), a household in our population of interest has two potential outcomes; the potential outcome for OSFP utilization when the household is exposed to nutrition awareness (y_1), and the potential outcome when the household is not exposed (y_0). Letting d indicate exposure to nutrition awareness, where $d = 1$ indicates that a household is exposed and $d = 0$ indicates otherwise, the observed outcome can be written as

$$y = (1 - d)y_0 + dy_1 = y_0 + d(y_1 - y_0) \quad (1)$$

of interest is the OFSP utilization outcome, with and without exposure to nutrition awareness, $y_1 - y_0$. Since we can only observe a household at one state i.e., either exposed to nutrition awareness or not, it is not possible to measure $y_1 - y_0$ for a given household. Under the conditional independence assumption (Rosenbaum & Rubin, 1983), we can estimate the effect of treatment based on the observed random vectors $\left((y_i, d_i, x_i)\ i \dots n\right)$ using a randomly drawn sample from the population of interest, where y is OFSP utilization outcomes, d is the indicator of nutrition awareness, and x is a list of covariates determining exposure to nutrition awareness, for household i. The average treatment effect (*ATE*) can then be estimated by taking expectation of the difference in outcomes with and without exposure to nutrition awareness, i.e.,

$$ATE = E\{y_{i1} - y_{i0} | d = 1\} + E\{(y_{i0} | d = 1) - E(y_{i0} | d = 0)\} \quad (2)$$

where the first term on the RHS is the *average treatment effect on the treated* (ATET), or the OFSP utilization outcomes for the group that received nutrition awareness interventions, while the second term is the *average treatment effect on the non-treated* (ATENT), or the potential OFSP utilization outcomes for the group that did not receive nutrition awareness interventions, had they received these.

Under the conditional independence assumption, the treatment status d is independent of the potential outcomes y_1 and y_0, conditional on a set of observed covariates x. This assumption allows for the matching of households in the treated and untreated groups based on similarities in pretreatment observable characteristics (x) and averaging the differences in the outcomes between the matched units (Dehejia & Wahba, 2002). This is the main tenet of the propensity score matching (PSM) method. In the first step, we estimate a Probit model for the probability of being exposed to nutrition awareness,

$$p(x) = P(d = 1 | \boldsymbol{x}) \quad (3)$$

where the function $p(x)$ is the response probability for treatment (probability of being exposed to nutrition awareness), also known as the *propensity score.* Given the estimated conditional probability to treatment allocation $\hat{p}(x)$, three estimators are then obtained in the second step of the estimation process,

$$ATE = \frac{1}{N}\sum_{i=1}^{N}\frac{\{d_i - \hat{p}(x_i)\}y_i}{\hat{p}(x_i)\{1-\hat{p}(x_i)\}}$$

$$ATET = \frac{1}{N}\sum_{i=1}^{N}\frac{\{d_i - \hat{p}(x_i)\}y_i}{\hat{p}(d=1)\{1-\hat{p}(x_i)\}} \qquad (4)$$

$$ATENT = \frac{1}{N}\sum_{i=1}^{N}\frac{\{d_i - \hat{p}(x_i)\}y_i}{\hat{p}(d=0)\hat{p}(x_i)}$$

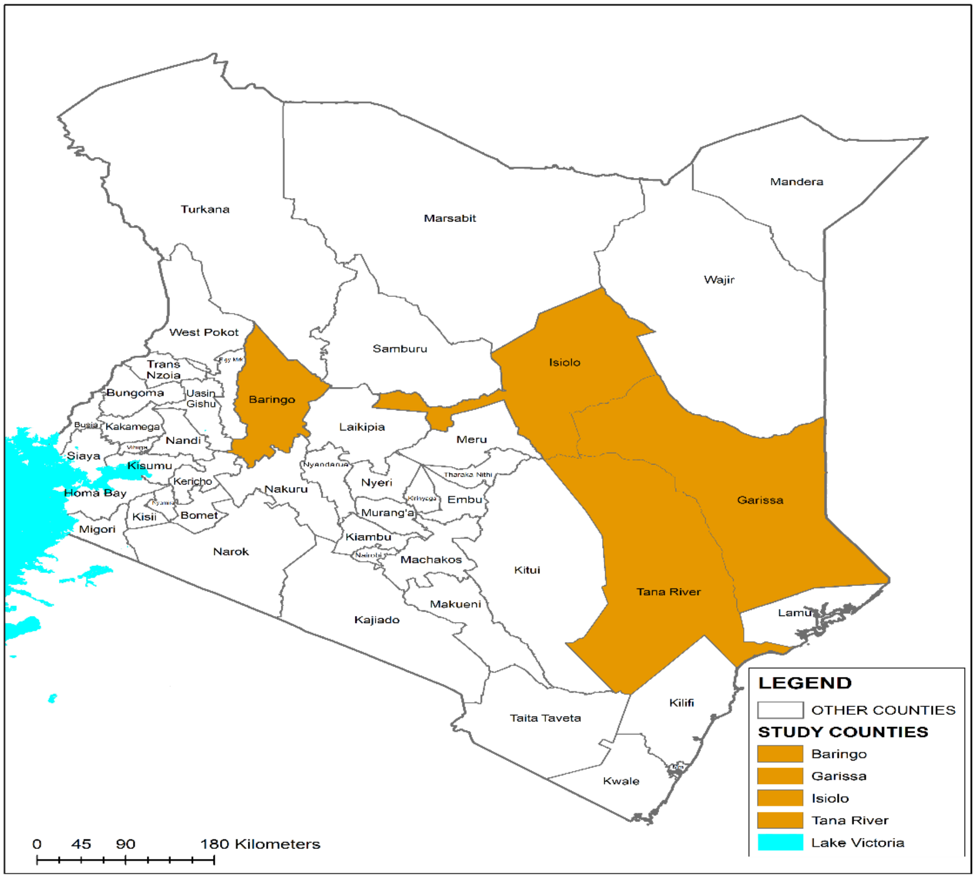
where ATE is the OFSP utilization outcomes for the overall population; $ATET$ is the OFSP utilization outcomes for the group exposed to nutrition awareness; $ATENT$ is the potential OFSP utilization outcomes for the non-exposed group; and other terms on the RHS are as defined before.

The identification strategy described above identifies two sources of non-randomness in our data, i.e., non-exposure and self-selection biases. While propensity score attempts to match the treated and non-treated units by the observable characteristics (x), the two groups may exhibit different distributions over these characteristics given the systemic differences due to the identified biases. Cerulli (2014) developed an algorithm to balance the distribution of the observable covariates between treated and non-treated units, in the case of non-randomness in treatment assignment. We follow this method in reweighting the observations based on their probability of being exposed to nutrition awareness (household propensity scores). In the implementation procedure, we first implement a Probit estimation of equation (3), build weights for the treated observations ($1/p_i$) and for the untreated ones ($1/1 - p_i$), then calculate the estimators in equation (4) by comparing the weighted means of the two groups. These steps are implemented in STATA using the *treatrew* procedure developed by Cerulli (2014).

4. Data

4.1 Data sources and sampling

Primary data was collected in the months of May-July 2021 from four counties in the ASAL regions of Kenya, namely Garissa, Tana River, Isiolo and Baringo. Quantitative data was collected from households using a semi-structured questionnaire, while qualitative data was collected from county nutrition and agricultural extension officers, as well as community members and leaders, using focus group discussions (FGDs) and key informant interviews (KII's). In this study, we use the household survey data to analyze the effect of nutrition awareness on OFSP utilization, and the qualitative data to further understand the insights behind observed results. These insights are also used to further ground the attribution of observed effect of nutrition awareness on OFSP utilization to interventions led by CIP-WFP.



Source: Global Administrative Areas Database (April 2018)

Date: 12/1/2021

Figure 1: map of study area

To identify households for the household survey, a multistage sampling procedure was used; in the first step, the four counties of study were purposively selected based on their sweetpotato production potential. Next, WFP field officers working with county agricultural officers assisted in compiling a list of all sweetpotato producing areas within these counties. The list also indicated administrative areas (locations, sub-locations and villages) where CIP-WFP interventions on scaling out OFSP were being promoted. This formed a basis for stratifying the clusters for inclusion in the study, with villages stratified as either areas of intervention or otherwise. Finally, random-proportionate to size sampling was utilized to select 550 households spread across 51 villages in 26 locations of the four counties.

4.2 Description of key variables

In this section, we describe the various variables used in the study, as well as provide the descriptive statistics for these.

Nutrition awareness

This is the main predictor (*treatment)* variable in our study. To elicit this, respondents were asked if they had information about Vitamin A and its nutritional importance, as well as knowledge of OFSP and its benefits in boosting Vitamin A intake. The nutrition awareness variable thus obtained is a composite variable and could be achieved through any of the promoted CIP-WFP interventions in the area. Given that these interventions in the study region are channeled through various change agents, including health clinics for pregnant mothers, schools, and public extension (see Figure 2), it may not be feasible to directly elicit participation in a single CIP-WFP intervention, as a treatment variable. For example, information flow through participating beneficiaries may diffuse from the individual to other household members and friends, as well as spillover to neighboring households. The reasonable assumption made is that observed nutrition awareness is due to any of the CIP-WFP intervention arms, either through direct beneficiaries or through community spillovers.

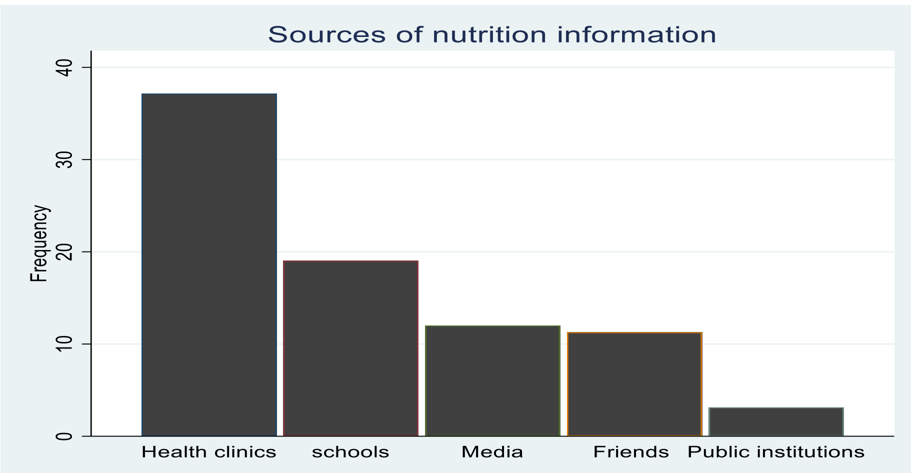


Figure 2: Sources of nutrition information

As shown in Figure 2, friends and relatives is a major source of information, similar to the targeted intervention of using the media, an indication of positive spillovers. Health clinics and schools formed the bulk of information sources for the respondents who had nutrition awareness, while use of public institutions like extension and research centres were the least sources of information.

OFSP consumption

We asked respondents about number of times OFSP was consumed in their households in the previous one month. Specifically, this was asked for household members less than 5 years old and pregnant and/or lactating mothers (most vulnerable groups to VAD). Given the low numbers of pregnant and lactating mothers in the sample and in line with extant literature (Wilde et al., 1999), this category was revised to refer to female household members of child-bearing age.

Table 1: Descriptive statistics

Variable	Exposed to nutrition awareness (n=368)	Non-exposed to nutrition awareness (n=166)	Test for difference in means		Overall (n=539)	
	Mean	Mean	Mean	Std error	Mean	SD
Exposure to nutrition awareness (%)					68.9	-
Outcome variables						
OFSP utilization	21.5	10.2	11.2***	0.032	17.7	-
Times consumed OFSP last one month	2.06	0.54	1.52***	0.386	1.59	3.28
Household head characteristics						
Female-headed (%)	42	40	2.0	-	41.6	-
Education	7.0	5.3	-1.7***	0.44	6.5	4.8
Age	45	50	4.6***	1.29	46	13.9
Household characteristics						
Group membership	26.6	15.2	-2.91***	0.004	23.0	-
Access to extension	15.2	7.2	-2.33**	0.020	12.9	-
Distance to market	55.2	66.2	10.84**	4.81	58.9	51.7
Pregnant woman in household	20.9	14.2	-1.77*	0.077	18.7	-
Fixed effects						
Baringo county					34.9	-
Tana river county					17.9	-
Garissa county					18.4	-
Isiolo county					28.7	-

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The main outcome variable is therefore a continuous variable of the number of days in the previous one month that any of these two member groups in a household (i.e., women of child-bearing age and children under 5 years of age) had consumed OFSP. With the redefinition, the overall sub-sample for this analysis increased to 539 observations, out of the 550 interviewed households (see Table 1).

Other explanatory variables

Variables hypothesized to be important in explaining exposure to nutritional information include sociodemographic variables such as sex, age and education of household head, group membership, proximity to markets and access to extension. Consistent with previous literature on exposure to- and adoption of- technologies, female-headed households are hypothesized to be less exposed to nutritional information while higher educated heads are more likely to exposed to nutritional information. A quadratic relationship between age and exposure to nutritional information is expected, with older household heads more exposed to nutritional information until a maximum point where increase in age induces less exposure to nutritional information.

Following literature on technology diffusion theory, membership to groups is expected to be positively correlated to exposure to nutritional information, similar to access to extension advice. On the other hand, a negative relationship between exposure to nutritional information and proximity to markets is expected, with households far away from markets expected to be less exposed to nutritional information. This follows the use of traders as information nodes for nutritional information, as one of the WFP-CIP intervention entry points. To improve on model identification, we also include an indicator variable of whether a household has a pregnant woman at the time of the study, as one of the entry points of the WFP-CIP interventions was dissemination of nutritional information through trained pre- and post-natal clinic workers, as trainer of trainers (ToTs). This variable is therefore hypothesized to be positively correlated with exposure to nutrition awareness.

5. Results

Results of the study are presented in this section. First, results from the Probit estimation of determinants to exposure to nutrition awareness are presented, followed by those on the effect of nutrition awareness on OFSP utilization. The latter incudes a comparison of results obtained from a reweighted propensity score and those obtained from the endogenous switching regression.

5.1 Determinants of exposure to nutrition awareness

Results on the determinants to nutrition awareness are presented in Table 2. Consistent with existing literature, female-headed households were shown to be less likely to be exposed to nutrition information. This is despite the CIP-WFP intervention strategy of targeting women, especially the pregnant and lactating mothers using the health clinics approach. One explanation to this puzzle is that women from female-headed households, which have been shown by literature to be resource poor (Felker-Kantor & Wood, 2012), are less likely to attend pre- and ante-natal clinics in these regions. As a result, while the targeting strategy manages to get many women in the intervention, these are likely to come from households that are less resource and time constrained, and which are mainly male headed. There is need to therefore revise the targeting strategy to include women who are less likely to attend such clinics, for inclusive impacts of the interventions. Similarly, heads of households with higher formal education had a higher likelihood of being exposed to nutrition awareness. In a region where much of the population has low levels of formal education, interventions aimed at scaling out utilization of OFSP need to be sensitive to education-related barriers.

Table 2: Determinants of exposure to nutrition awareness

VARIABLES	Vitamin A & OFSP awareness
Household head sex	-0.272**
	(0.131)
Household head education	0.0811***
	(0.0168)
Household head age	0.00812
	(0.0280)
Household head age-squared_	-0.000173
	(0.000276)
Group membership	0.296*
	(0.172)
Extension access	0.548**
	(0.235)
Distance to market	-0.00220*
(Walking minutes)	(0.00118)
Pregnant woman in household	0.471***
	(0.173)
Tana river county	0.381*
	(0.204)
Garissa county	0.679***
	(0.176)
Isiolo county	1.008***
	(0.219)
Constant	-0.263
	(0.726)
Observations	528

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Institutional related factors such as market and extension access were also found to be significant in explaining exposure to nutrition awareness. Specifically, households with access to extension service were more likely to be exposed to nutrition awareness, while those further away from main markets were less likely to be exposed. One of the intervention strategies employed by CIP-WFP in disseminating nutrition information is through training of traders in sweetpotato about the importance of OFSP, as well as offering support to these market actors. It therefore follows that households closer to markets where such traders operate are more likely to benefit from such interventions. Incidentally, households further away from markets are more likely to be vulnerable to malnutrition, as nutritional diversity for these households depends more exclusively on own production. Deepening market access through support to village level traders may thus be an intervention entry point for facilitating access to a new crop like OFSP.

Similarly, the CIP-WFP suite of intervention packages includes training of public extension officers on nutrition awareness, for the onward dissemination of the same to farming households. Targeting local-based extension agents, at lower administrative units and those close to farmers will therefore achieve higher adoption of OFSP for producing households.

5.2 Impact of nutrition awareness on OFSP utilization

Results on the effect of nutrition awareness on OFSP utilization are presented in this section. Table 3 presents results from the analysis using the propensity score matching approach, where the first two columns are results from the re-weighted propensity score and the last column is from a one-to-one nearest neighbor matching algorithm. Column two represents results obtained using bootstrapped standard errors (BS SE) while column one represents results obtained using analytical standard errors (A SE). Column two results are discussed in this section, given the improvement in the results precision using the bootstrapped standard errors compared to those in column one. Results from the one-to-one nearest neighbor matching in column three are presented for comparison purposes. For robustness checks, we also present results of from an estimation using the endogenous switching regression method (Table 4).

Table 3: Results from re-weighted and one-to one propensity score matching

VARIABLES	Number of days consumed OFSP last one month		
	Re-weighted propensity score		One-one matching (Nearest neighbor)
	A SE	BS SE	A/BS SE

ATE	1.113***	1.113***	1.448***
	(0.378)	(0.395)	(0.407)
ATET	1.143*	1.143**	1.540
	(0.611)	(0.471)	(0.389)
ATENT	1.043	1.043***	1.233**
	(1.218)	(0.390)	(0.557)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results show that on average, exposure of households in the study area to nutrition information (ATE) leads to about a day (1.11) of OFSP consumption within a month's time. This population average effect is slightly lower to that of the households who were exposed to nutritional awareness (ATET) in the CIP-WFP interventions, who had about 1.14 days of OFSP consumption within the previous month. For the households that were not exposed to nutritional information (ATENT), these would have had about a day (1.04) of OFSP consumption within the previous month, had they been exposed to nutritional information. These results highlight the importance of creating awareness as a first step to enable adoption and utilization to OFSP, consistent to others obtained by Adekambi et al. (2020) who showed that mere knowledge of OFSP varieties increased adoption of OFSP varieties significantly in Ghana and Nigeria.

Table 4: Results from endogenous switching regression

	With nutrition awareness	Without nutrition awareness	Treatment effect
Households with nutrition awareness (ATET)	2.1(0.08)	1.0 (0.05)	1.09 (0.10) ***
Households without nutrition awareness (ATENT)	1.3(0.14)	0.6 (0.08)	0.67 (0.16) ***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results from the endogenous switching regression support those obtained from the propensity score estimations. Controlling for other covariates determining utilization of OFSP and the selection bias from both observed and unobserved heterogeneity, exposure to nutrition awareness led to significant improvements to OFSP utilization. Specifically, households that are exposed to nutrition awareness have higher OFSP utilization rates (about two days a month) compared to the counterfactual situation had they not been exposed (about a day of OFSP utilization a month), giving an overall utilization effect of about 1.1 days of OFSP consumption per month. This result is similar to one obtained above in the PSM approach for households exposed to nutritional awareness. For the households that are not exposed to nutrition awareness, their OFSP utilization rate of 0.6 days in a month is significantly lower to the counterfactual outcome, had they been exposed (1.3 days of OFSP consumption a month), giving a potential effect of about 0.7 days on OFSP consumption in the previous one month.

6. Discussion and conclusions

Vitamin A deficiency (VAD) continues to afflict vulnerable populations in lower- and middle-income countries (LMICs), with those in fragile environments being affected the most. This study aims at providing early evidence on the effects of interventions led by the World Food Program (WFP) and the International Potato Center (CIP) through a partnership to enhance food and nutritional security in arid and semi-arid regions of Kenya. The study uses cross-sectional data and robust impact evaluation methodologies to understand the effect of raising nutrition awareness on utilization of orange fleshed sweetpotato (OFSP), a micronutrient (Vitamin A) rich biofortified crop. Further, the study assesses some of the intervening factors that determine exposure to nutrition awareness, with a view of identifying lessons to guide ongoing interventions to achieve biofortification at scale and inclusive impacts in the region.

Key factors determining exposure to nutrition awareness identified in the study include household characteristics like gender and education, and institutional factors like market and extension access. Consistent with the literature, female-headed households are less likely to be exposed to nutrition awareness, despite the CIP-WFP intervention strategy of targeting women, especially the pregnant and lactating mothers using the health clinics approach. There is need to therefore rethink this strategy, as participating women in these interventions are more likely to be drawn from households that are less resource and time constrained, which are mainly male headed. A more nuanced gendered strategy will ensure women from the most vulnerable households and who are unable to be drawn in the sample of women attending health clinics are also reached by the interventions. Similarly, household heads with lower levels of formal education are shown to have a lower likelihood of accessing nutritional information. Nutrition awareness interventions, such as those disseminated through the media, need to take this into account so as to reach these lowly-educated households, who are also some of the most vulnerable to malnutrition. Programming of nutrition information could for example be more focused on using local languages, as well as be accompanied by demonstrations, to improve on salience.

Distance to trader markets is negatively correlated with access to nutrition information. This could be driven by the CIP-WFP intervention strategy of training and supporting traders on OFSP importance and access, for onward dissemination to consumers. Households closer to such markets therefore benefit more on nutrition awareness, compared to those farther away. This implies that efforts to reach traders at village level markets would bring information and OFSP closer to consuming households, therefore improve on utilization. Similarly, access to extension advice improves the likelihood of access to nutrition information, which is also likely driven by the CIP-WFP intervention arm of training public extension officers on nutrition awareness, for onward dissemination to farming households. An integrated approach of targeting extension agents both at county and lower administrative levels, e.g., location levels, would ensure nutrition information is brought closer to vulnerable households who are far from county extension offices. This is especially important given the current agricultural extension policy in the country that is more demand- rather than supply- driven.

The results also identify clear positive effects of access to nutrition awareness on OFSP utilization. These results, though modest (on average about a day of OFSP utilization in a 30-day period), are highly significant and clearly show the potential of the CIP-WFP interventions in enhancing biofortification in the ASAL regions of Kenya. Given that these interventions are still at nascent stage, the results are quite encouraging as to the potential success of such interventions in enhancing OFSP utilization in the region. Further, considering that this analysis focuses solely on interventions aimed at raising nutrition awareness, combining such with other interventions meant to mitigate both demand and supply side constraints (for example, higher accessibility to OFSP vines at affordable prices, WFP's cash transfer program for vulnerable households and linkages to OFSP markets, greater market spread and supporting higher market supply of OFSP roots for non-producing households, etc.), the potential impacts can only be expected to be higher.

References

Adekambi, S. A., Okello, J. J., Abidin, P. E., & Carey, E. (2020). Effect of exposure to biofortified crops on smallholder farm household adoption decisions: The case of orange-fleshed sweetpotato in Ghana and Nigeria. *Scientific African*, *8*, e00362. https://doi.org/10.1016/j.sciaf.2020.e00362

Asfaw, S., Pallante, G., & Palma, A. (2018). Diversification Strategies and Adaptation Deficit: Evidence from Rural Communities in Niger. *World Development*, *101*, 219–234. https://doi.org/10.1016/j.worlddev.2017.09.004

Atanu, S., Love, H. A., & Schwart, R. (1994). Adoption of Emerging Technologies Under Output Uncertainty. *American Journal of Agricultural Economics*, *76*(4), 836–846. https://doi.org/10.2307/1243745

Cerulli, G. (2014). Treatrew: A user-written command for estimating average treatment effects by reweighting on the propensity score. *Stata Journal*, *14*(3), 541–561. https://doi.org/10.1177/1536867x1401400305

Dehejia, R. H., & Wahba, S. (2002). Propensity score-matching methods for nonexperimental causal studies. *Review of Economics and Statistics*, *84*(1), 151–161. https://doi.org/10.1162/003465302317331982

Diagne, A., & Demont, M. (2007). Taking a new look at empirical models of adoption: Average treatment effect estimation of adoption rates and their determinants. *Agricultural Economics*, *37*(2–3), 201–210. https://doi.org/10.1111/j.1574-0862.2007.00266.x

Dimara, E., & Skuras, D. (2003). Adoption of agricultural innovations as a two-stage partial observability process. *Agricultural Economics*, *28*(3), 187–196. https://doi.org/10.1016/S0169-5150(03)00003-3

Felker-Kantor, E., & Wood, C. H. (2012). Female-headed households and food insecurity in Brazil. *Food Security*, *4*(4), 607–617. https://doi.org/10.1007/s12571-012-0215-y

Foley, J. K., Michaux, K. D., Mudyahoto, B., Kyazike, L., Cherian, B., Kalejaiye, O., Ifeoma, O., Ilona, P., Reinberg, C., Mavindidze, D., & Boy, E. (2021). Scaling Up Delivery of Biofortified Staple Food Crops Globally: Paths to Nourishing Millions. *Food and Nutrition Bulletin*, *42*(1), 116–132. https://doi.org/10.1177/0379572120982501

Girard, A. W., Grant, F., Watkinson, M., Okuku, H. S., Wanjala, R., Cole, D., Levin, C., & Low, J. (2017). Promotion of orange-fleshed sweet potato increased vitamin A intakes and reduced the odds of low retinol-binding protein among postpartum Kenyan women. *Journal of Nutrition*, *147*(5), 955–963. https://doi.org/10.3945/jn.116.236406

Gitonga, Z. M., Visser, M., & Mulwa, C. (2020). Can climate information salvage livelihoods in arid and semiarid lands ? An evaluation of access , use and impact in Namibia. *World Development Perspectives*, *20*(August), 100239. https://doi.org/10.1016/j.wdp.2020.100239

Heck, S., Campos, H., Barker, I., Okello, J. J., Baral, A., Boy, E., Brown, L., & Birol, E. (2020). Resilient agri-food systems for nutrition amidst COVID-19: evidence and lessons from food-based approaches to overcome micronutrient deficiency and rebuild livelihoods after crises. *Food Security*, *12*(4), 823–830. https://doi.org/10.1007/s12571-020-01067-2

Hotz, C., Loechl, C., De Brauw, A., Eozenou, P., Gilligan, D., Moursi, M., Munhaua, B., Van Jaarsveld, P., Carriquiry, A., & Meenakshi, J. V. (2012). A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. *British Journal of Nutrition*, *108*(1), 163–176. https://doi.org/10.1017/S0007114511005174

Hotz, C., Loechl, C., Lubowa, A., Tumwine, J. K., Masawi, G. N., Baingana, R., Carriquiry, A., de Brauw Meenakshi, A., & Gilligan, D. O. (2012). Introduction of β-Carotene-Rich orange sweet potato in rural Uganda resulted in increased vitamin a intakes among children and women and improved vitamin a status among children. *Journal of Nutrition*, *142*(10), 1871–1880. https://doi.org/10.3945/jn.111.151829

Jenkins, M., Shanks, C. B., Brouwer, R., & Houghtaling, B. (2018). Factors affecting farmers' willingness and ability to adopt and retain vitamin A-rich varieties of orange-fleshed sweet potato in Mozambique. *Food Security*, *10*(6), 1521–1523. https://doi.org/10.1007/s12571-018-0866-4

Kassie, M., Teklewold, H., Marenya, P., Jaleta, M., & Erenstein, O. (2015). Production Risks and Food Security under Alternative Technology Choices in Malawi: Application of a Multinomial Endogenous Switching Regression. *Journal of Agricultural Economics*, *66*(3), 640–659. https://doi.org/10.1111/1477-9552.12099

Low, J. W., & Thiele, G. (2020). Understanding innovation: The development and scaling of orange-fleshed sweetpotato in major African food systems. *Agricultural Systems*, *179*(December 2019), 102770. https://doi.org/10.1016/j.agsy.2019.102770

Mulwa, C.K., & Visser, M. (2020). Farm diversification as an adaptation strategy to climatic shocks and implications for food security in northern Namibia. *World Development*, *129*. https://doi.org/10.1016/j.worlddev.2020.104906

Mulwa, C. K, Muyanga, M., & Visser, M. (2021). The role of large traders in driving sustainable agricultural intensification in smallholder farms: Evidence from Kenya. *Agricultural Economics (United Kingdom), October 2019*, 329–341. https://doi.org/10.1111/agec.12621

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41–55. https://doi.org/10.1017/CBO9780511810725.016

Shikuku, K. M., Okello, J. J., Sindi, K., Low, J. W., & Mcewan, M. (2019). Effect of Farmers' Multidimensional Beliefs on Adoption of Biofortified Crops: Evidence from Sweetpotato Farmers in Tanzania. *Journal of Development Studies*, *55*(2), 227–242. https://doi.org/10.1080/00220388.2017.1414188

Simtowe, F., Asfaw, S., & Abate, T. (2016). Determinants of agricultural technology adoption under partial population awareness: the case of pigeonpea in Malawi. *Agricultural and Food Economics*, *4*(1). https://doi.org/10.1186/s40100-016-0051-z

Terza, J. V, Basu, A., & Rathouz, P. J. (2008). Two-stage residual inclusion estimation: addressing endogeneity in health econometric modeling. *Journal of Health Economics, 27*(3), 531–543. https://doi.org/10.1016/j.jhealeco.2007.09.009

Van Der Straeten, D., Bhullar, N. K., De Steur, H., Gruissem, W., MacKenzie, D., Pfeiffer, W., Qaim, M., Slamet-Loedin, I., Strobbe, S., Tohme, J., Trijatmiko, K. R., Vanderschuren, H., Van Montagu, M., Zhang, C., & Bouis, H. (2020). Multiplying the efficiency and impact of biofortification through metabolic engineering. *Nature Communications*, *11*(1), 1–10. https://doi.org/10.1038/s41467-020-19020-4

Wilde, P. E., McNamara, P. E., & Ranney, C. K. (1999). The Effect of Income and Food Programs on Dietary Quality: A Seemingly Unrelated Regression Analysis with Error

Components. *American Journal of Agricultural Economics*, *81*(4), 959. https://doi.org/10.2307/1244338

Wooldridge, J. M. (2002). Econometric Analysis of Cross Section and Panel Data. *MIT Press: Cambridge, MA, USA*. https://doi.org/10.1515/humr.2003.021