EFFECTS OF INTEGRATED NUTRITION EDUCATION APPROACHES ON PRODUCTION AND CONSUMPTION OF ORANGE-FLESHED SWEETPOTATOES IN HOMA BAY COUNTY, KENYA

BY

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This thesis is my original work and has not been presented for an award of a degree in any other University.

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DEDICATION

I dedicate this thesis to my parents Mr. Philip Ojwang' Otieno and Mrs. Jane Akinyi Ojwang', siblings Beryl, Quinter, Jacob, Andrew, Collins, Selestine, Mercy and friends. It takes a village…!

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LIST OF ABBREVIATIONS AND ACRONYMS

AVCD	Accelerated Value Chain Development
BCC	Behavior Change Communication
CIP	International Potato Center (*Centro Internacional de la Papa*)
ECD	Early Childhood Development
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GLM	Generalized Linear Model
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
KAP	Knowledge, Attitude and Practices
NCPD	National Council for Population and Development
OFSP	Orange-Fleshed Sweet Potato
RCT	Randomized Control Trials
SDGs	Sustainable Development Goals
SRM	Special Regressor Model
SSA	Sub-Saharan Africa
UNICEF	United Nations Children's Education Fund
USAID	United States Agency for International Development
VAD	Vitamin A Deficiency
WFP	World Food Programme
WHO	World Health Organization
ZIP	Zero-Inflated Poisson

ABSTRACT

Malnutrition is still a big menace in sub-Saharan Africa as approximately 48 percent of children below five years and 20 percent of pregnant-age women suffer from the effects of Vitamin A deficiency (VAD); night blindness, increased child morbidity and mortality. Biofortified staples have been promoted widely in the region as a sustainable way of addressing the undernutrition problem. Recent studies have shown that these foods can contribute to the fight against malnutrition, and are accepted by young children. However, the existing initiatives used in promoting the vitamin A biofortified orange-fleshed sweetpotato (OFSP) have borne fruits, whose impacts have seldom been felt beyond the borders of the direct beneficiaries and the active periods of the projects. Nevertheless, the potential role of simultaneous nutrition education dissemination to preschool children and their caregivers on the continued production and consumption of fresh biofortified food remain much less understood. Thus, the main objective of this study was to assess the effects of disseminating nutrition education to preschool children and their caregivers on the production and consumption of OFSP.

The objectives of the study were to assess the effects of integrated nutrition education approaches on; i) the caregivers' knowledge, attitude and practices (KAP) around OFSP; ii) the caregivers' likelihood to replant OFSP after phase-out of the free vines dissemination projects; and iii) the consumption of OFSP among preschool children. The study was guided by the random utility theory and employed a randomized controlled trial approach. Participants were selected through a multistage sampling technique. The first stage gave a purposive sample of 15 villages that had no prior interaction with OFSP promotion projects in the Ndhiwa and Rangwe Sub-counties of Homa Bay County. The second stage involved using proportionate to size sampling and simple random sampling techniques to choose 431 preschooler-caregiver pairs who

participated in preliminary activities of the study - cooking demonstrations and dissemination of free vines. The 15 villages were randomized into four groups (one control and three treatment groups) and all participants in the groups were assigned the respective interventions. The treatments involved the issuance of nutrition education; i) to preschool children alone via OFSP-branded exercise books, class posters, and poems; ii) to caregivers alone by sending bulk nutrition education messages to their phones; and iii) to both the preschooler and the caregiver simultaneously using the same methods in other treatment arms. Baseline and follow-up survey data were collected using structured questionnaires. Also, a dietary diversity register was used to collect data on the preschoolers' consumption of OFSP during school days. The effects of the treatments were elicited by estimation of the generalized linear regression model (GLM), special regressor method (SRM), and the zero-inflated Poisson (ZIP) regression model in line with the three hypotheses, respectively.

The results show that only the multiple-channel oriented nutrition education gave significant improvements in all the dimensions of the caregivers' knowledge of OFSP. It also improved the likelihood of the caregivers to retain the OFSP on their farms significantly while the single-channel approaches failed to provide any significant improvements. Further, both the single and multiple-channel oriented nutrition education approaches increased the number of days on which the preschool children were fed on the OFSP roots. Overall, the magnitude of the effect of OFSP nutrition education interventions was significantly improved by delivering the nutrition education through multiple channels and ensuring higher rates of reception of the assigned interventions by the target group. Accordingly, the study concludes that the integration of complementary nutrition education interventions, delivered through the Early Childhood Development (ECD) platforms, can enhance the supply of and demand for nutritious crops such

as OFSP in the menus of malnutrition high risk groups to improve food and nutrition security. The study recommends that agriculture-nutrition education interventions should consider both preschoolers' learning materials and the caregivers' mobile phones as effective platforms for nudging the caregivers to adopt the biofortified staples sustainably.

Key words: malnutrition; nutrition education; orange-fleshed sweetpotato; replanting; consumption.

CHAPTER ONE: INTRODUCTION

1.1 Background

Despite the concerted global efforts to address the problem, undernutrition prevalence has increased from 785 million people in 2015 to 821 million in 2018 (FAO et al., 2019). Due to this, more than 3 million children are lost per year to malnutrition, as 155 million of the under 5-year-old are stunted. One key contributor to child and maternal malnutrition is hidden hunger - deficiency in essential vitamins and micronutrients, which has strong devastating effects on the physical and cognitive growth and development of young children.

Vitamin A deficiency (VAD), a form of micronutrient deficiency, affects the immune system of individuals, thereby jeopardizing their health and increasing the risks of poor cognitive development; morbidity, especially from diarrhea and measles; and mortality (WHO, 2015; Rice et al., 2004). It has also been linked to increased rates of mother-to-child transmission of the Human Immunodeficiency Virus (HIV) in addition to the progression of diseases among HIV-positive adults and general immune functions linked to severe visual impairment and blindness (Annan, 2011; McHenry et al., 2015; WHO, 2018).

Bio-fortification is a technology that boosts the density of vitamins and minerals in the plant food through agronomic practices and breeding so that when consumed regularly, they would create measurable improvement in the vitamin and mineral status (Zikankuba et al., 2019). The technology is promoted globally to enhance the nutrition conditions of targets. Besides, it is highly cost-effective at the rate of $15-$20 per disability-adjusted life year (DALY) saved (Bouiss and Saltzam, 2017; Meenakshi et al., 2010). Orange-fleshed sweetpotato (OFSP) is a leading case of a vitamin A biofortified product that is promoted and embraced by the target

society in equal measures. It has better agronomic and nutritional traits, including faster maturity, high yield potential and endowed with rich-nutrients (Low et al., 2017).

Agriculture-nutrition sensitive programs have been promoted as relatively more sustainable and cost-effective strategies for addressing the malnutrition problem among rural farming households in the global south, especially the SSA (Olney et al., 2019; Ruel et al., 2013&2018; Ruel, 2018; Zikankuba et al., 2019). However, according to contemporary reviews, the potential of the agri-nutrition education programs on nutrition security is way far from full realization. Nonetheless, there is an active line of positive evidence that links these programs to improvements in the nutritional status of the target groups. What is lacking is concerted effort to design more differentiated and effective agriculture-nutrition programs to help scale up the fight against malnutrition beyond the current rates (Olney et al., 2019; Ruel et al., 2018; Zikankuba et al., 2019.

The nutrition-sensitive interventions have followed the principle of targeting and integrating vulnerable groups to maximize project impacts (Bos et al., 2015). Accordingly, rural farming households are encouraged to change their farming routines and dietary behavior if they are to sustainably adopt the OFSP (Zikankuba et al., 2019). That is, for the continuous availability of the OFSP in their menus, farmers need to conserve the vines and plant them in consecutive planting seasons and consume OFSP as they harvest from their farms. In order to influence such changes, research has shown that well designed and carefully implemented nutrition-sensitive agricultural programs can improve young-child and maternal nutrition when they include information on the agronomic and nutritional benefits of the food crop, strong behavior change communication (BCC) and interventions that empower women (Rue et al., 2013; Muehlhoff et al., 2017; Mutiso et al., 2018).

For a long time, most of the nutrition-sensitive programs focused on the 1000 days of a young child and left out the preschool child (mostly 2-6 years) until they joined the primary school levels (Bos et al., 2015; Gelli et al., 2018). This realization has led to a shift in intervention targeting protocols, to include the Early Childhood Development (ECD) platform, to enhance the fight against malnutrition. Nevertheless, nutrition is critical to the overall health and well-being of an individual throughout their life cycles, thus the need to train a child towards healthy nutritional decisions from the tender age.

Women and children are the most vulnerable groups to VAD cases. Therefore, interventions that aim to eradicate VAD perform better if they reach this target group (Ruel et al., 2017). Previous studies have shown that children can be effective nudges to their parents, and several studies have reported significant differences in interventions that used children as change agents (Murimi et al., 2017&2018). However, the potential effect of engaging preschoolers and their caregivers with intensive nutrition education is limited in the empirical literature. Consequently, such collective avenues that bring together the malnutrition-vulnerable groups could be losing their potential in contributing to the fight against malnutrition. In essence, integrating agriculture-nutrition education interventions through the ECD platform may provide a mechanism for accelerating the scalability and effectiveness of the food-based strategies against malnutrition.

Early Childhood Development and Education (ECDE) centers in Kenya are managed by the county governments. They play an important role in providing learning and holistic development of children, mostly between 3 and 5 years. Homa Bay county has 1183 such centers with an enrolment rate of 76% (County Government of Homa Bay, 2018).

In the context of this study, a preschooler is defined as a child between 3 and 7 years who has not been introduced to the primary level of school (Grade 1), but is linked to the nearby ECD institution. A caregiver refers to the person who prepares and feeds the preschooler in the household.

1.2 Statement of the Research Problem

Despite being highly endowed with relatively fertile agricultural land, favorable agro-climatic conditions and two planting seasons, Homa Bay county is still faced with a high rate of undernutrition (Bernstein and Wiesmann, 2018; Delorme et al., 2018). It is also recognized as one of the leading producers of sweetpotato in Kenya (Abong et al., 2016). Conventional malnutrition eradication strategies (such as vitamin A supplementation, industrial food fortification) have persistently underserved the population. For instance, the 2-dose vitamin A supplementation program, implemented by the county government, reportedly served only 42 percent of under-5-year old children in 2017 (County Government of Homa Bay, 2018). A larger share of the county is rural, and farming is the main livelihood activity. The OFSP was introduced in the county more than a decade ago; however, the spread of the residents' awareness and active engagement with the crop for nutrition security beyond the direct beneficiaries and the promotional project periods is limited.

Nutrition education has been promoted as one of the best methods of implementing behavior change communication, to empower the vulnerable target groups towards making effective changes in dietary and nutrition-related behaviors (Marias and Glasauer, 2014; Mutiso et al., 2018). Recent studies have targeted elementary schools with nutrition programs, suggesting that such integration could help improve the cognitive and nutritional well-being of the children – thereby enhance their likelihood of achieving their full potential as adults. However, most of the

programs have not yet incorporated the preschool children as change agents with behavior change communication strategies involving their caregivers independently or simultaneously, thus a missed opportunity. In essence, while there is a developing line of studies involving the ECD institutions in the promotion of improved nutrition outcomes, the role of this phenomenon when preschool children are integrated as change agents is an essential gap in literature. Therefore, exploring the evidence base on effective ways to scale-up the biofortified technologies (OFSP) through ECD-centered complementary agriculture-nutrition education interventions will be necessary.

1.3 Objectives of the Study

The main objective of this study was to assess the effect of ECD-integrated complementary nutrition education approaches on the production and consumption of OFSP among preschoolers and their caregivers. The specific objectives pursued were:

1. To assess the effects of integrated nutrition education approaches on caregivers' knowledge, attitude and practices around OFSP.
2. To assess the effects of integrated nutrition education approaches on the replanting of OFSP among farming households after the lapse of free vines seasons.
3. To assess the effects of integrated nutrition education approaches on consumption of OFSP among preschoolers.

1.4 Research Hypotheses

1. Integrated nutrition education approaches do not improve the knowledge, attitude and practices (KAP) of caregivers regarding OFSP.

2. Integrated nutrition education approaches do not improve the likelihood of the caregivers to replant OFSP after the lapse of the free vines dissemination projects.

3. Integrated nutrition education approaches do not increase the consumption frequency of OFSP among preschoolers.

1.5 Justification

Children and women of reproductive age are the most vulnerable groups to VAD (World Health Organization, 2018). It is imperative to ensure that the interventions aimed at eradicating this type of malnutrition have a direct focus on the vulnerable group as both the change agents and primary targets of the projects and programs for desired nutrition outcomes. Recent literature strongly highlights the fact that prevalence of malnutrition within a society is not only due to insufficient access to quantity and quality food but also unreliable utilization of the same. The latter factor is heavily dependent on the production and consumption behavior of the vulnerable group. The result of this study will help the entire stakeholders in the fight against malnutrition to improve their understanding of the effectiveness of nutrition education with preschool children and their caregivers in enhancing the pathways to improved nutrition security.

The second and third sustainable development goals (SDGs) of the United Nations Development Program (UNDP) aim at eliminating poverty and hunger and ensuring sustainable health and well-being of the society. People in the rural areas of the developing countries are reported to perform relatively more poorly on the relevant indicators of economic welfare, food and nutrition security, and the general health and wellbeing of individuals (Shetty, 2018). There is, therefore, a critical need for improvement in the policies and programs that are implemented by the government and development partners towards achieving the goals. Understanding the

appropriateness of nutrition education approaches as explored in this study will help the stakeholders with effective designing, planning, and implementation of agriculture-nutrition interventions that have improved the potential of realizing the SDGs that targets eradication of hunger in all its forms.

The prevalence of malnutrition over the centuries has prompted the development and implementation of different approaches in a bid to end the menace. The appropriateness of these approaches varies with different factors, including the demographics of the target group, the financial demand and supply, and the scalability given the geographic distribution of the target.

Food-based approaches have been promoted as the best approaches for developing countries with relatively weak financial support to fund supplementation and the rural societies that cannot continuously afford to purchase the fortified industrial products. Nutrition education, on the other hand, is aimed at improving knowledge and motivating positive behavior change among the target households and individuals towards nutritionally responsive behaviors. This study combines both the food-based approach (production of biofortified crops) and nutrition education to demonstrate the unexplored potential of such integrated approaches in realization of the pathways to nutrition security. In essence, this study contributes to the literature on effective targeting and integration of nutrition education and its delivery approaches aimed at promoting sustainable adoption of food-based approaches in rural farming households.

More than 1.8 million children are chronically undernourished in Kenya. The focus of the study on improving the pathways to nutrition security is, thus, intrinsically and instrumentally significant. First, children have a constitutional right to grow-up healthy and well-nourished (Republic of Kenya, 2014). Secondly, chronic-undernutrition has long-lasting effects that persist

into adulthood (especially the physical and psychological consequences of stunting). Therefore, it is imperative to instill fundamental knowledge of good nutritional practices among the young generation.

Malnutrition in general poses a significant burden in economic and social development of individuals and the nation at large. Kenya lost a total of Kshs 373.9 billion (6.9 percent of GDP) in 2014 as the total effect of child undernutrition on health, education and productivity (Republic of Kenya, 2019). The far-reaching effects of malnutrition on human capital, labor productivity and the overall attainment of the economic development goals, call for strategic multisectoral approaches rather than treating malnutrition as an exclusive public health problem. A focus on eradicating malnutrition has positive effects towards the attainment of critical tenets of the Kenya's Vision 2030, which targets to reduce stunting to 14.7 percent and underweight to 8.4 percent. It aims to secure a place for Kenya in the list of the most competitive global economies with high quality of life (Republic of Kenya, 2008). Nutrition is also a critical component of the Kenya's 5-year-rapid-development blue-print, the "Big 4 Agenda", which also targets 100 percent food and nutrition security. The findings of this study will make significant contribution to inform the policy makers towards designing food and nutrition intervention approaches to achieve rapid results in nutrition security and make profound contribution to the national and global food and nutrition policies.

1.6 Study Area

The study was conducted in Homa Bay county, one of the leading producers of sweetpotato in Kenya. Also, the county was of particular interest as it hosted a large project that aimed at scaling up the production and consumption of OFSP to reduce the high incidence of malnutrition (Okello et al., 2019). More than half the population of under-2-year old children in the county

are malnourished (Republic of Kenya, 2014). However, most households have a child of between 3 and 5 years old, with 76 percent enrolled in ECD centers (County Government of Homa Bay, 2018). Also, more than half the households in the county grow sweetpotato for both subsistence and commercial purposes, with women playing a significant role in the production activities (Opiyo et al., 2010). These conditions make ECD centers a good avenue for reaching out to the households with under-5-year olds with nutrition initiatives. They also make OFSP an essential vehicle for delivering vitamin A and eradicating micro-nutrient malnutrition in the county.

The county is located in the western part of Kenya and is divided into eight sub-counties; Kasipul, Ndhiwa, Kabondo-Kasipul, Rangwe, Karachuonyo, and Homa Bay Town Sub-Counties. It has an outstanding primary school net enrollment rate of 98 percent, which makes researching with children a reliable representation of the households in the periphery of the schools (NCPD, 2017). Figure 1 shows a map of the county with the specific study villages marked by location pointers in an enlarged map. The different colours of the location pointers refer to the randomization of the villages into different study groups will be discussed in the proceeding sections.

1.7 Organization of the Thesis

This thesis is organized into six chapters. The context of the study, research problem, objectives, hypotheses and justification for the study have been presented in chapter one. In chapter two, there is an in-depth issue-based review of relevant literature. Further, chapter three focuses on the assessment of changes in the caregivers' knowledge, attitude and practices due to nutrition education interventions. In chapter four, the effects of the nutrition education interventions on the retention of OFSP in the subsequent planting season are presented. Chapter five provides an

analysis of the effects of the interventions on the frequency of consumption of OFSP among preschool children. Finally, chapter six presents the general summary of the main findings, conclusion of the study and recommendations to policy makers and for further research.

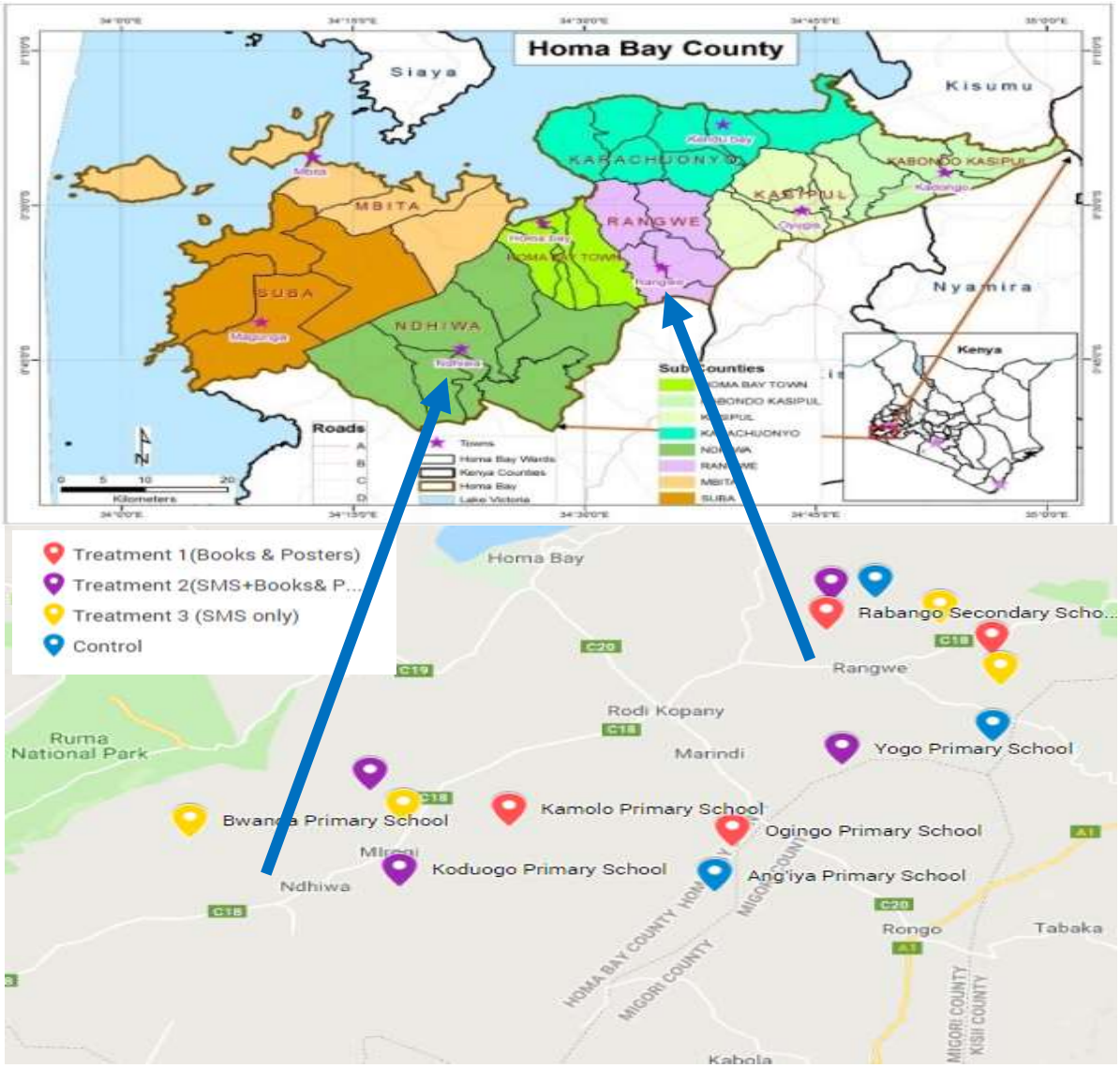

Figure 1: The Map of Study Locations in Homa Bay County, Kenya

Source: The Independent Electoral and Boundaries Commission (2018) and Google Maps.

CHAPTER TWO: LITERATURE REVIEW

2.1 The Role of Nutrition Education in Enhancing Behavior Change and Nutrition Security

The concept of nutrition education aims to influence the voluntary adaptation of food choices and nutrition-related behaviors conducive to health and well-being (Muehlhoff et al., 2017). It models and improves people's motivation to learn eating well and enhances their ability to do so. Contento (2016) elaborates that nutrition education targets the individual while at the same time addressing institutional, community and policy levels. Empirical evidence argues for the use of nutrition education to enhance adoption and acceptability of the new agriculture-nutrition sensitive technologies such as bio-fortification, and in particular, enhance the feeding practices by nudging the incorporation of the new nutritious food types into the diet diversity campaigns and practice at household and individual levels (Low 2017; Mutiso et al., 2018; Nabugoomu et al., 2015; Okello et al., 2019).

Compared to the controls (in the absence of nutrition education), provision of nutrition education significantly improved women and young children's dietary diversity and mothers' intention to incorporate OFSP in complementary feeding practices in Kenya and Malawi (Kuchenbecker et al., 2017; Mutiso, 2017; Waswa et al., 2015). It also increased child dietary diversity (CDD) and selected nutrients and energy intake in Ethiopia. In other instances, as in Ghana, it has been integrated with other approaches such as entrepreneurship education, micro-credit loans and cash transfer programs to significantly improve the nutrition status of children (Negash et al., 2014; Marquis et al., 2015). In all these studies, nutrition education was employed as a vehicle to influencing voluntary behavior change. However, the previous studies did not report on any aspect of the sustainability of the interventions or their delivery approaches. It is imperative to

note that the sustainability of an intervention is not just on its ability to realize desired changes/results in the target population long after the lapse of the project but also the potential of its continued execution to the target group for a relatively longer and more effective period for a wider impact in the society (Bos et al., 2015; Okello et al., 2019; Orsendarp et al., 2018). Thus, there is a growing demand to develop and demonstrate a high-level impact and readily scalable interventions (Olney et al., 2019). The present study involves nutrition education through approaches that are potentially highly scalable by integrating the nutrition education in items that the target interacts with on a daily basis at personal levels.

2.2 A Review of Previous Nutrition Interventions with Preschool Children

Involving school children in nutrition intervention exercises has the potential to influence their food preferences throughout their lifetime (Andrade et al., 2009). Targeting of the subjects is a common practice in planning delivery and appraisal of nutrition-sensitive intervention in the research and development arena. Reviews of literature indicate that targeting the interventions to women and younger children during the first 1000 days, convey greater improvements on the children's nutritional status (Bryce et al., 2008; Bhutta et al., 2008). However, there is insufficient evidence on which specific targeting approach or platform works best.

Promotion of OFSP has been targeted through several platforms, including the health facilities, schools, women and farmers' social clubs, and the ECD platforms. A recent study in Malawi (Gelli et al., 2018) targeted parenting groups through the ECD platform with agri-nutrition interventions to improve the preschoolers' nutritional outcomes. The design of the Malawian study involved offering a series of agriculture training and nutrition education to the preschoolers' parents at the ECDs, on production and inclusion of nine different nutritious foods

in the preschoolers' diets. They saw greater increases in the nutrient intake and dietary diversity of children in the intervention group relative to the control. An agriculture-nutrition intervention integrated through the ECD platform improved the dietary diversity preschoolers and reduced the stunting of children in Malawi (Gelli et al., 2018). In the previous studies involving ECD platforms, such as the Malawi study, children have only been used as primary targets of the interventions and platforms for measuring the project outcome with the caregivers involved in the supply of the materials to the schools. However, the present study involved the preschoolers as change agents. In addition, unlike in Gelli et al. (2018), the present study involved nutrition education as a complementary intervention after routine agriculture and nutrition interventions.

2.3 Treatment Effects

Treatment effect refers to the average causal effect of a dummy variable on an outcome variable of interest (Twisk et al., 2018). The use of the term has evolved over time from its original concept in the medical literature in line with the causal effect of binary variable interventions such as a trial drug or testing a new surgical procedure. While several methods could be applied to estimate the causal effect of an intervention, there are basic issues that often lead to the elimination of one method after another from their application for such courses. The most common issue is the point of selection bias (Athey and Imbens, 2017).

Randomized evaluations have been proven to be the solution to challenges of selection bias and have since been adopted in several scientific studies. The principle approach is to randomly assign the sample into groups; the treatment and the control groups. While a group is treated with the intervention, the control is not; then, the outcome is observed and compared between both

groups. The effect of the intervention is measured as the empirical difference in the outcome of the control and treatment groups.

This method has been applied in several studies in agriculture and nutrition (Liu et al., 2009; Diagne and Demont, 2007; Benin, 2015). Hackman and Knowlden (2014) urge that new behavior-based interventions in diets should focus on using randomized control trial (RCT) research designs over the quasi-experimental and quantitative designs on the basis that randomization ensures equality between groups, while the rest do not. Further, clustered RCTs have been proven to maintain high quality and rigor relative to other approaches (Hemming et al., 2017). However, it is imperative to note that using RCT will always demand consideration of mixed models to assess the potential loss of independence that may exist in an individual (Hackman and Knowlden, 2014). The current study employed the clustered RCT design with measurement of the outcomes done at individual levels rather than the cluster level. Further, in estimation of the treatment effects, the potential bias in randomization and intra-cluster correlation are accounted for in the regressions models by controlling for the differences between the groups at baseline and having cluster robust standard errors in the estimation, respectively.

2.4 Consumption of OFSP

The OFSP is highly endowed with vitamin A and other micronutrients, which makes it a favorable food for all in a household, especially those at risk of malnutrition. Frequent consumption of OFSP is thus, recommended for improved nutritional status of the targets. Whilst, a small serving of 100g-125g provides the daily vitamin A requirement of under-5-year old children, frequent intake of the same is necessary to enhance the contribution of the other nutrients. Many studies have assessed its acceptance and likelihood of being consumed by the

targets. However, few of these have explored the frequency of its consumption among the targets. Loechl et al. (2010) and Sakala et al. (2018) are the most recent studies on OFSP consumption frequency and were carried out in Kenya and Zambia, respectively. They note that OFSP consumption among school children is related to vines access, production and exposure to nutrition education.

Contrary to the previous studies, the present study evaluates the effects (causal) of the interventions on OFSP consumption frequency as opposed to just the relationship between the two. It is important to explore the underlying determinants of OFSP consumption since owing to the African perception of sweetpotato as a food security crop (that cushions the household from hunger when the key staples such as maize and rice are out of supply or of limited accessibility) its consumption is conventionally seasonal (Low et al., 2017). For instance, Sakala et al. (2018) acknowledge that carrying out the study during the sweetpotato harvesting season may have contributed to the high OFSP consumption scores realized. Without accounting for such factors as production, it can be misleading to make inferences based on the relative differences in the percentage of the consumers and the non-consumers or the consumption frequency scores. In addition, instead of using the 7-day-recall food frequency questionnaire, the present study collected the food consumption data using an adjusted food consumption diary to increase the precision of data owing to a relatively shorter recall period.

2.5 Conceptual Framework

The overarching goal is to sustainably eradicate VAD by enhancing the consumption of the vitamin A-rich OFSP. External interventions are expected to leverage the determinants of the desirable changes based on the underlying causal assumptions to enhance the realization of the

desired outcomes. Figure 2 below provides the framework of the pathways through which providing complementary agriculture-nutrition education can improve the nutritional status of the households by effecting changes in OFSP consumption and vitamin A intake among preschool children.

Firstly, the agriculture/production pathway; the caregivers receive planting materials and are offered agronomic and nutrition education on how to cultivate the crop and its nutritional benefits, respectively. It leverages the OFSP food supply for improved food availability and accessibility in the household. However, the complementary interventions can bolster the efforts towards ensuring sustained production of the roots and enhance the supply of vitamin A-rich food.

Secondly, through the psychosocial pathways, the caregivers can be empowered with appropriate knowledge and attitude towards OFSP, which would boost their likelihood to consume it. They typically play an important role in looking after the children - feeding and providing health care. Therefore, the nutritional and health status of the child depends on a complex interaction between the caregiver and the child. This also depends on the caregiver's socio-economic and environmental factors within the setting that they reside (WHO, 2004). In addition, the child's nutritional status also depends on the caregiver's autonomy, which is subject to their empowerment levels (Carlson et al. 2014; Ahmed et al., 2014). Nonetheless, children also have the potential to influence the caregivers' behavior on food choices, health and nutrition practices (WHO, 2004; Murimi et al., 2017).

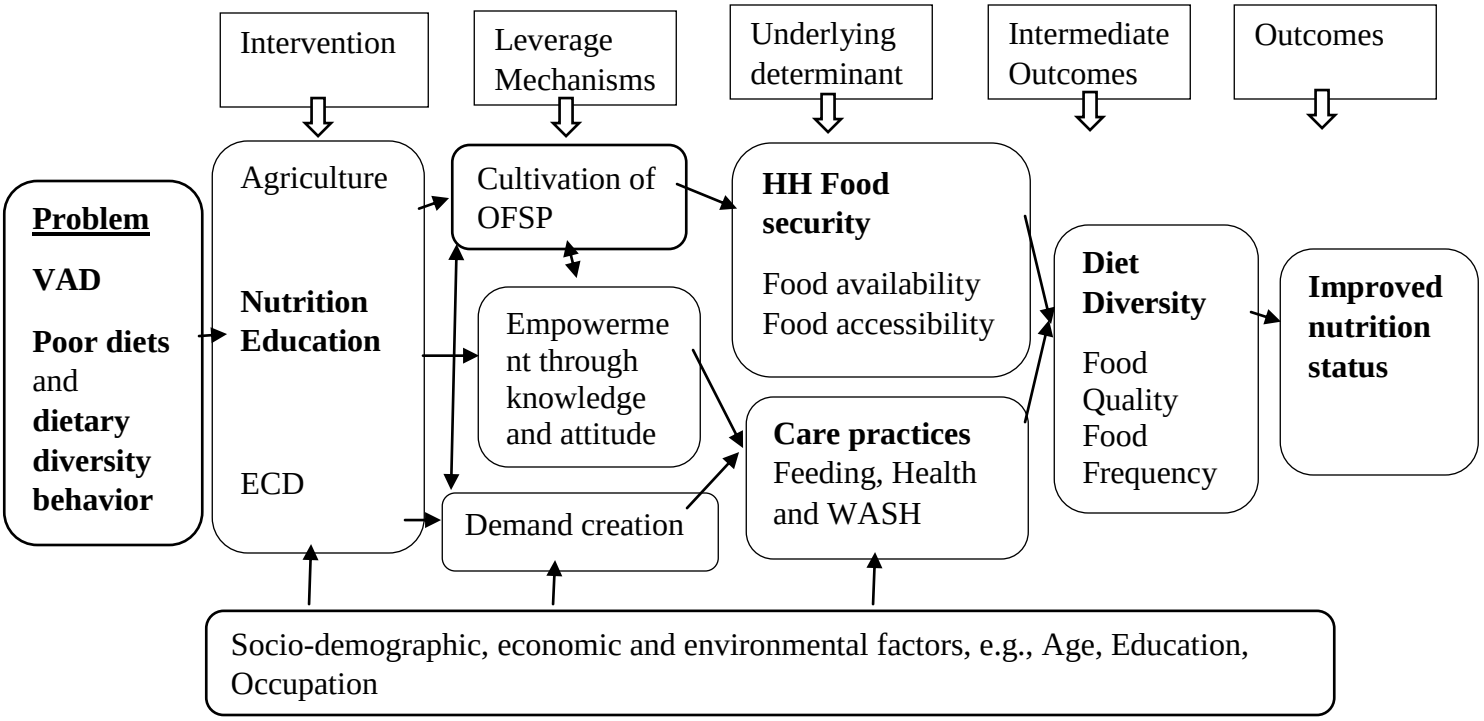

Figure 2: Conceptual Framework of How Nutrition Education Contribute to Improved Nutritional Status among Young Children

Source: Adapted from Achadi et al. (2016) and Low et al. (2007)

The third pathway of demand creation involves enhancing the acceptance of the nutritious food on the menus, which would have a ripple effect on the efforts to ensure its sustainable supply. Rural farming households often consume what they produce. Leveraging the supply of the crop is thus important for the sustainable intake of vitamin A in the society.

2.6 Theoretical Framework

The study is based on the random utility framework to model the decision to replant and consume OFSP roots independently. In such a scenario, the caregiver as a decision-maker is assumed rational and chooses that option that gives the best-expected utility from a set of alternatives (Greene, 2003). Thus, a caregiver makes the decision to cook OFSP in the household

for themselves and their children if the perceived utility expected from such actions exceeds that of the alternative.

The utility function representing the decision to replant or otherwise (*D)* can be stated as:

$$D = I(X'\beta + \varepsilon \geq 0) \quad \ldots\ldots \quad (1)$$

where X is the vector of explanatory variables, β is a vector of the unknown parameters to be estimated, and ε is the error term. Both objectives 2 and 3 follow a similar model structure. The decision to replant OFSP (1) and prepare a meal with OFSP (2), in this case, will be influenced by a number of factors, key among them; whether or not they receive the nutrition information, comprehension of the nutrition information that one receives, the channel of disseminating the nutrition education information, socio-economic characteristics of the preschooler and the caregiver, village specific factors such as environmental issues among others.

CHAPTER THREE: EFFECTS OF INTEGRATED NUTRITION EDUCATION APPROACHES ON CAREGIVERS' KNOWLEDGE, ATTITUDE AND PRACTICES REGARDING OFSP

3.1 Abstract

Biofortified staple crops are increasingly being promoted to combat micronutrient deficiencies. However, their uptake has been slow. Recent efforts to enhance the cultivation and consumption of these crops by rural households have targeted elementary school children as agents of change. This study examined the effects of promotional activities targeting preschoolers and their caregivers and extolling the benefits of these crops. The objective of this chapter was to assess the effects of targeted nutrition education involving preschool children and their caregivers on their knowledge, attitude and practices (KAP) relating to OFSP. The study randomly assigned 431 preschooler-caregiver pairs to one control and three treatment/intervention groups. All the caregivers had participated in cooking demonstrations and received free vines. For 30 days, the treatment groups received the interventions as follows: Treatment 1 – OFSP-branded exercise books and class posters to the preschoolers only; Treatment 2 – phone-mediated text messages to caregivers only; and Treatment 3 – both interventions in 1 and 2 simultaneously. The control group only received free vines and participated in cooking demonstrations. Baseline and follow-up data were collected from caregivers. The results show that the multiple-channel nutrition education approach had the largest positive effect on caregivers' knowledge of OFSP, vitamin A and its consumption. However, only the phone-mediated messaging approach significantly improved attitude towards OFSP. This study concludes that a multiple-channel approach targeting caregivers and preschoolers with nutrition education is effective in increasing knowledge of the cultivation and consumption of biofortified crops.

3.2 Introduction

Contemporarily, OFSP is promoted as the best food-based approach to combat VAD globally and the leading bio-fortification success story. International development organizations such as the International Potato Center (CIP) and the national governments have devoted considerable efforts to promote its production and consumption. Notably, multiplication and distribution of free vines to rural households have been the dominant activities in the OFSP scaling up programs to improve production, market access, and availability of the roots to the households. However, there is also a strong considerable observation that increased income, improved production diversity, or reduced pressures on time may be of little or no nutrition value in the absence of the relevant knowledge among the target population (Pinstrup-Andersen, 2014; Acharya, 2018).

Besides, recent studies have observed that many cases of poor nutrition among the rural households are attributable to poor psychosocial constructs among the vulnerable groups regarding the nutritious food and good dietary practices (Acharya, 2018). Complementary to food availability issues, poor attitudes and practices which include long-established dietary habits, poor agricultural production decisions, negative attitudes towards certain food types (especially vegetables), and food distribution habits in the family are some of the most considerable constraints to nutrition security among many rural households today (Acharya, 2018; FAO, 2011). However, executing active and well-structured nutrition education could change the trend (FAO, 2011; Tanumihardjo et al., 2010). Improved knowledge and attitude on OFSP production, nutritional composition and benefits, and substantive preparation methods for consumption may improve its acceptance and availability in the diets of the rural farming households.

Households have to make changes in their dietary practices to actively integrate OFSP and other nutrient-rich foods in their diets, which require social and behavior change approaches (Gibson, 2014; USAID, 2014). Nutrition education is one of the strategies that have commonly been employed to influence changes in dietary practices by communicating the benefits of given foods in the diets (Guldan et al., 2000; USAID, 2014; Kuchenbecker et al., 2017; Okello et al., 2019; Zinkankuba et al., 2019). This points to the critical need for the integration of nutrition education with other efforts to ensure the success of nutrition-sensitive initiatives. However, the pre-existing nutrition education interventions as catalysts in the nutrition-sensitive agriculture programs, have seldom engaged both the VAD high-risk groups (under-5-year old children and women of reproductive age), simultaneously (Kuchenbecker et al., 2017). Nevertheless, despite the strong evidence on the effectiveness of school-based nutrition education on alleviating hunger and improving the micronutrient status of the children, there is a limited understanding of this phenomenon with preschool children as the subject of the interventions. Against this background, this chapter assessed the effects of nutrition education interventions with preschool children and their caregivers on their knowledge, attitude, and practices among the rural farming households in Homa Bay county, Kenya.

Further, with adaptation from literature (Marias and Glasauer, 2014), OFSP knowledge is defined as the caregiver's understanding of proper OFSP cultivation, nutritional composition and benefits, and preparation for consumption essentials. Attitude is defined as the emotional, motivational, and cognitive belief that can positively or negatively influence the behavior of the caregiver on feeding themselves and the child on OFSP. Finally, practice refers to the observable actions of the caregiver that could affect the production and consumption of OFSP by the entire household. The objective of this chapter is to assess the effects of nutrition education

interventions with preschool children and their caregivers on their knowledge, attitude, and practices among the rural farming households in Homa Bay County, Kenya.

3.3 Methodology

3.3.1 Sampling and Selection of Participants

A multi-stage sampling method was employed. In the first stage, two sub-counties - Ndhiwa and Rangwe - were purposively selected as areas where CIP had been executing the Feed the Future's Accelerated Value Chain Development project of tubers; promotion of production and consumption of OFSP. Secondly, 15 villages where OFSP had not been introduced were purposively selected in the two sub-counties. In each selected village, one government-run ECD Center was selected for the study, resulting in a selection of 15 ECD centers. Next, households with preschool children attending the selected ECD centers were listed, and caregivers of the enrolled children invited to cooking demonstration workshops, in which the benefits and recipes of OFSP were discussed and demonstrated. The workshops were conducted in February 2018. Each caregiver then received free OFSP vines, amounting to 200 cuttings of 30 centimeters each, in April 2018. The caregivers who participated in the cooking demonstrations, and received the free vines, formed the study sampling frame. A random sample of 431 preschooler-caregiver pairs was drawn from the sampling frame for the experiment – 158 from Ndhiwa and 273 from Rangwe. The sampled preschooler-caregiver pairs were proportionate to the size of the population of children enrolled at the ECD centers.

3.3.2 Sample Size Determination

The sample size was calculated following McConnell and Vera-Hernandez's (2015) formula that is applicable in cases of cluster-level randomized studies – studies where interventions are targeted and issued at group levels rather than individual levels:

$$n = mk = D\left[\left(Z_\alpha + Z_\beta\right) * \frac{\left(P_1(1-P_1)+P_2(1-P_2)\right)}{(P_2-P_1)^2}\right](1+(m-1)\rho) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

m = the average number of individuals per cluster, while k = the number of clusters, p_1 is the level of an indicator estimated as a proportion at baseline or for the control area, while p_2 is the expected level of an indicator at a future date after the experiment such $p_2 – p_1$ is the magnitude of change that is desired to be detected. Z_α is the z score corresponding to confidence level (1-α) at the researcher can desirably conclude that the observed magnitude of change ($p_2 – p_1$) is not due to chance. Z_β = the z score corresponding to the level of confidence desired to be certain of detecting the changes of magnitude $P_2 – P_1$ in the indicator if it actually occurred (β – statistical power). Further, $(1+(m-1)\rho)$ is the variance inflation factor or the design effect of the randomization. In addition, the intra-cluster correlation (ICC), ρ, is included to account for randomization at cluster levels.

Assuming an increase of 20 percentage points (due to the design of the study - a short window between harvesting season and follow-up survey) in the proportion of households who conserve and replant OFSP in the subsequent season after the free vines dissemination season, an expected average of 26 respondents per cluster (m) and a low intra-cluster correlation (ρ) of 0.01. Using a standard parameter of 95 percent level of confidence (1-α) and 90 percent statistical power (β), and a low intra-cluster correlation (ρ) of 0.01, inserting these values in the formula in Equation 2 above yields:

$$=2\left[2.8^2 * {}^{0.2}/_{0.04}\right] * 1.25 = 98$$

This gives an average of 98 respondents per group.

Further, after adjusting to 4 study groups (control and 3 treatment arms) and a possible 10 percent non-response rate the final sample size is 431. The non-response rate was arrived at from recent literature done in the study area (Mutiso, et al., 2018; Mutiso, 2017).

$$=98 * 4 * 1.1 = \sim 431$$

3.3.3 Experimental Design and Interventions

The study followed a randomized controlled trial design with preschooler-caregiver pairs as participants. The pairs were randomly assigned into 4 study groups (one control and three treatment groups) based on the 15 village-level clusters. In addition to the participation in cooking demonstrations and receiving vines, the treatment groups received nutrition education interventions in three distinct approaches based on the information dissemination channels. The control group, on the other hand, only participated in the cooking demonstration workshop and got free vines but did not receive nutrition education. The respective treatments are described below:

3.3.3.1 Preschooler Treatment (PT)

The PT group received OFSP-branded exercise books, poems, and class posters, given to the preschool children alone. The book-covers and posters had pictorial illustrations of OFSP and a brief description of the health benefits of OFSP to the preschooler and the family, with text in *Dholuo*, the local language (see *Appendix A1* and *A2*). Lastly, the group also received an English-language poem also printed in the book covers and posters. There were five messages

passed through these materials, hence five different categories of books and class posters. Each preschooler in this group received an exercise book while their class teachers displayed the five posters in the classroom and helped them read out the posters and recite the poem on every school day. The goal was to influence the children to take the messages home and persuade/nudge their caregivers to grow and consume OFSP. That is, the preschoolers were to act as change agents and influence their caregivers' KAP regarding OFSP production and consumption.

3.3.3.2 Caregiver treatment (CT)

In this treatment group, each caregiver received a short text message on their mobile phones every day for thirty days. Each day, one of the seven messages (including those printed in the preschoolers' book covers) was sent uniformly at a prescheduled time (see *Appendix A3*). Thus, one message was sent each day of the week for seven days and repeated four times over the 30-day intervention period. In line with the laws of Kenya, all text messages were verified and approved by the Communication Authority of Kenya before being deployed to the designated treatment group (Republic of Kenya, 2013).

3.3.3.3 Integrated Treatment (IT)

The IT group concurrently received both interventions received by the PT and CT groups. In essence, for each household in this group, the caregiver was sent mobile-phone-mediated messages on OFSP for 30 days, the preschooler got an OFSP branded exercise books, had the OFSP posters mounted in their classroom read out to him/her and recited a poem with nutritional benefits of OFSP each school day education messages.

3.3.4 Data Collection

Data were collected from caregivers using individually administered pre-tested and validated household survey questionnaires (see *Appendix B*) at baseline and after a 30-day follow-up period, in August 2018 and October-November 2018, respectively. Verbal informed consent was obtained from all the caregivers before proceeding with the interviews. A total of 390 and 360 complete interviews were conducted during the baseline and follow-up surveys, respectively. The difference was due to absenteeism and refusal to participate in the follow-up survey. The questionnaires captured data of the caregivers' socio-demographics, KAP regarding OFSP, caregiver engagement with the interventions, household food security status using the household insecurity (access) scale (HFIAS), and other institutional factors related to production and utilization of OFSP.

3.3.5 Measurement of Caregivers' KAP Constructs

Based on the literature (Marias and Glasauer, 2014; Okello et al., 2014; Trakman et al., 2017), the dimensionality and reliability of various KAP survey segments were assessed before the computation of the variables. Three separate dependent variables were used in the subsequent analyses.

3.3.5.1 Knowledge

Following an exploratory factor analysis of the baseline KAP data, the caregivers' knowledge on OFSP was measured by a set of 19 items, which loaded into three factors: OFSP production knowledge (9 items), consumption knowledge (4 items), and vitamin A knowledge (6 items). The production and consumption knowledge items were presented with three-point response choices: 'No,' 'Yes,' and 'Don't know.' For both the positively and negatively framed

statements, codes 0, 1 and 2 were entered for an incorrect, correct, and ‘Don’t know’ responses, respectively. In line with the suggestions of Denman et al. (2018) and Lietz (2010), the ‘Don’t know’ response was treated as an unanswered question to avoid penalizing respondents for their non-response to the items.

The vitamin A knowledge segment entailed a mix of dichotomous and continuous scale response items. The continuous scale items had two entries: the total number of responses given and the number of correct responses. The final measure of the caregivers' OFSP production, consumption, or vitamin A knowledge was computed as a ratio of an individual's total correct scores to the total possible scores from the total answers given. This gave a ratio scale of between 0 and 1. A value closer to 0 (1) implied a very poor (very good) knowledge level.

3.3.5.2 Attitude

The caregivers gave their levels of agreement or disagreement with 11 items portraying an individual's general attitude towards OFSP. The items were measured on a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Positive and negative statements were intermixed, and coding for the latter reversed as recommended by the literature (Lagerkvist et al., 2015; Mutiso et al., 2018). This was necessary to ensure consistent and reliable measurement of the attitude constructs where a strongly agree response to a positive statement was coded as 5 and 1 when the response was to a negative statement. From the codes, a minimum total score was 11, while a maximum was 55. A Cronbach's Alpha statistics of 0.78 (for 11 items) indicated that the set of items was reliable (Trakman et al., 2017). The attitude scores were computed as a ratio ranging from 0 to 1. A value close to 0 (1) implied a highly negative (positive) attitude towards OFSP.

3.3.5.3 Practices

A set of 15 items were used to assess the level of caregivers' use of recommended OFSP production practices. Behaviors associated with OFSP consumption were excluded from the analysis since they were assessed once - during the follow-up survey only. The items were measured using a dichotomous scale with 'no'/'yes' responses coded as 0/1. The "Kuder-Richardson Formula 20" test statistics of 0.73 against a threshold of 0.70 confirmed the reliability of the items in measuring the construct (Trakman et al., 2017). Total scores by an individual were divided by the total possible scores (15) to produce a ratio scale ranging between 0 and 1. A value closer to 0 (1) implied a highly poor (good) practice level.

3.3.6 Data Analysis

3.3.6.1 Exploratory Analysis

All data were entered and analyzed using Stata version 14.2. The analysis process began by executing descriptive statistics. An orthogonality test was done to ascertain that the assignment of the preschooler-caregiver pairs into the study groups was independent of their socio-demographic characteristics. Baseline differences in the socio-demographic and institutional factors across the study groups were assessed using the two-way ANOVA and Kruskal-Wallis tests for normally and non-normally distributed variables, respectively. Further, pairwise comparisons of differences of the variables across the study groups were executed with the Bonferroni adjustment method for multiple pairwise comparisons of means (using Stata command *dunntest*) (Dinno, 2015).

Additionally, Wilcoxon sign rank tests were used to evaluate within-group (each study group) differences in the caregivers' KAP scores between baseline and follow-up data. Between-group

differences in the mean changes in KAP scores (follow-up score minus baseline score) were also evaluated using Kruskal-Wallis tests and the Bonferroni correction method for multiple pairwise comparisons of independent sample means.

3.3.6.2 Estimation of Treatment Effects

Our primary outcomes of interest, the individuals' changes (follow-up minus baseline) in the relative KAP scores, appear on a continuous scale with values between -1 and 1. The OLS is the typical estimator for data with a continuous dependent variable. Following, McCullagh (2019), the analysis employed a generalized linear model (GLM) specified as presented in Equation 3 below:

$$Y_{ij} = \beta_0 + \beta_1 PT_{ij} + \beta_2 IT_{ij} + \beta_3 CT_{ij} + \beta_4 KAP_{ijt=0} + X'_{ij}\beta_n + \varepsilon_{ij} \quad \text{.....(3)}$$

where Y_{ij} is the change in the relative KAP scores for individual *i* in village *j*; and *PT*, *IT*, and *CT* are the random treatment group assignment variables coded as a dummy (1 for the given intervention group and 0 for being in the control group). The main parameters of interest β_1, β_2 and β_3 represent the estimated effects of the interventions on the caregiver's KAP scores. A measure of $KAP_t = 0$ is the relative score of the respective KAP constructs at baseline for individual *i*. The vector *X'* contains individual-level, household-level, and institutional variables that relate to psychosocial constructs on food items. The random error term is notated as ε_i.

Further, the wild cluster *bootstrap-t* procedure was employed to estimate the p-values for correct testing of the hypotheses - a solution to the problem of few clusters (because the study had only 15 unbalanced clusters divided by 4 study groups) (Cameron et al., 2008; Cameron and Miller, 2015; Duflo et al., 2008; Wooldgridge, 2003). The procedure provides adequate power for the assumption of the large sample theory by mimicking the given sample through multiple

replications and presents desirable false rejection rates for making statistical inferences independent of cluster sizes (Cameron and Miller, 2015; Menger, 2017). In essence, a generalized linear regression with wild cluster bootstrapping was used to estimate changes in individuals' relative KAP scores due to their assignment into different intervention groups relative to the control groups while controlling for their baseline KAP scores and other covariates.

Figure 3 below provides a graphical summary of the study design, activities and the timeline.

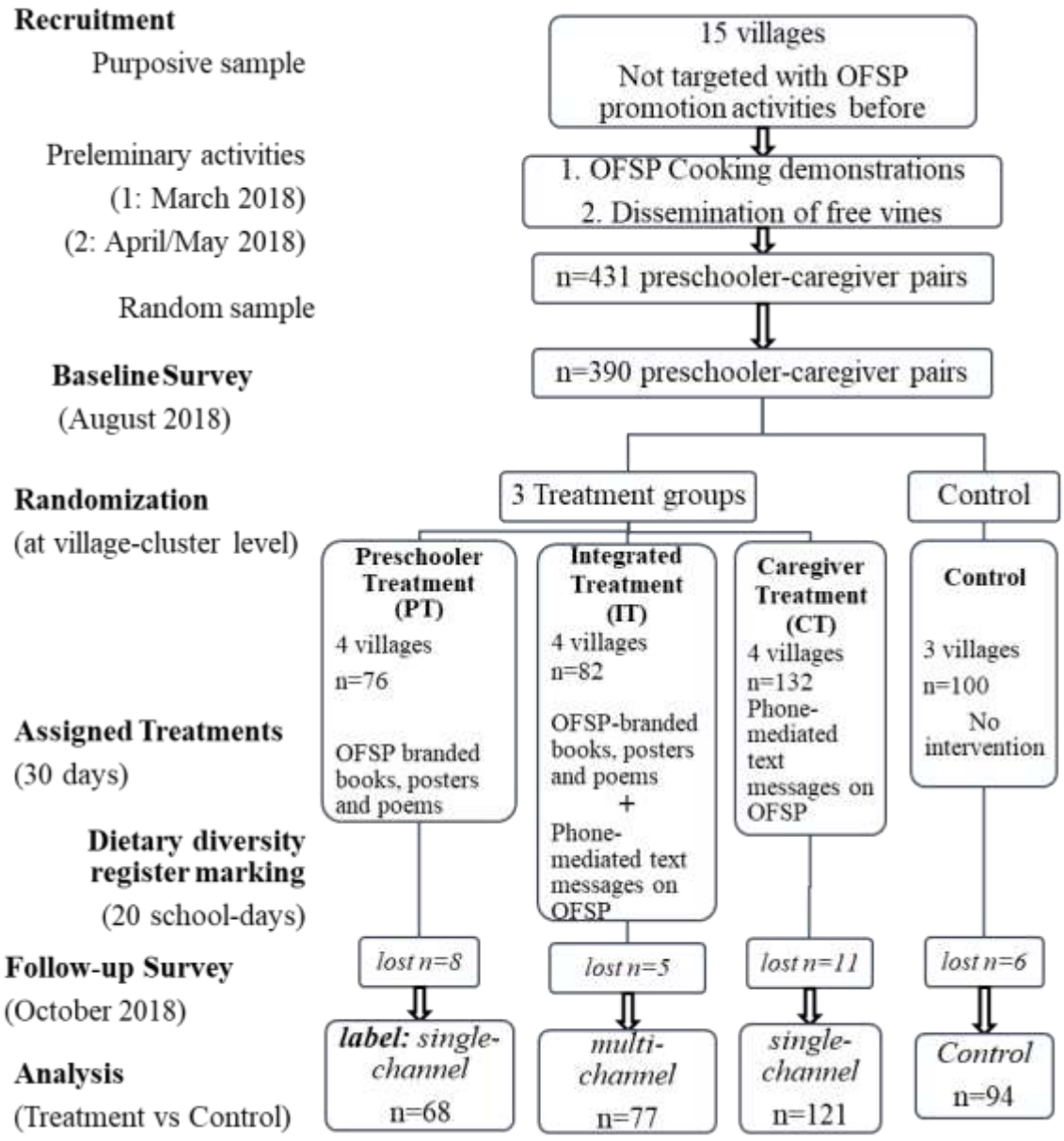

Figure 3: A consort diagram of the study

3.4 Results and Discussion

3.4.1 Attrition

A total of 390 caregivers from the 15 villages were surveyed at baseline, registering a response rate of 90.5 percent. The follow-up survey had 360 caregivers surveyed in all the 15 villages, leading to a 7.7 percent attrition rate among the targeted caregivers. Attrition was mainly attributable to refusals for re-interviews, death cases, and migrations from the area or transfers from the ECD center. However, there were no significant differences in the attrition rates between the study groups. The results in Table 1 demonstrate that there were no significant differences in means of the key outcome variables between the non-attrited and attrited (lost at follow-up) sample at baseline. In addition, Table 2 shows that there was no relationship between the probability of attrition and treatment assignment.

Table 1: Unadjusted Means and Differences in Means of the Main Outcome Variables at Baseline between the Attrited and Non-Attrited Sample

	Non-Attrited (n = 360)		Attrited (n = 30)		Difference	
Outcome Variables	Mean	SD	Mean	SD	Diff.	*p*-value
Knowledge of OFSP production	0.666	0.183	0.695	0.159	0.0295	0.392
Knowledge of OFSP consumption	0.923	0.174	0.942	0.204	0.0190	0.571
Knowledge of VA	0.600	0.297	0.573	0.323	-0.0273	0.630
Aggregate knowledge score	0.730	0.138	0.737	0.126	0.0071	0.787
Attitude towards OFSP	0.525	0.228	0.537	0.217	0.0124	0.773
Practice on OFSP	0.283	0.182	0.234	0.179	-0.0485	0.161
Grew OFSP from the free vines	0.675	0.469	0.600	0.498	-0.0750	0.403
Ever fed OFSP to their children	0.425	0.495	0.300	0.466	-0.1250	0.183
CDDS	4.328	1.239	4.300	1.088	-0.0278	0.905
HFIAS	11.789	5.937	9.867	6.479	-1.9222	0.091*
N	360		30			

, **, * imply significant at 10%, 5% and 1%, respectively.*

Source: Survey data (2018)

Table 2: Cross-tabulation and Chi-square Test for Significant Relationship between Study Groups and Attrition

Study groups	Attrited Counts (%)	Non-attrited Counts (%)	Total	Pearson's Chi-square	*p*-value>Chi^2
PT	8 (10.53)	68 (89.47)	76	1.6331	0.652
IT	7 (6.10)	77 (93.90)	82		
CT	11 (8.33)`	121 (91.67)	132		
Control	6 (6)	94 (94)	100		
Total	30 (7.69)	360 (92.31)	390		

Source: Survey data (2018)

3.4.2 Sample Characteristics

Table 3 presents the descriptions and summary statistics of the variables by the study groups. The last column presents the *p*-values of the results of the tests (one-way ANOVA, Kruskal-Wallis, and Chi-square tests) for differences in sample means between the four study groups. Further, multiple pairwise comparisons for differences in the variable means/proportions between the study groups were conducted, and the superscripts after the sample average statistics in the table present the results of the Bonferroni correction formula. Generally, there were no significant statistical differences in most of the socio-economic variables except for caregivers' mean age, monthly household expenditure, and accessibility of a community health volunteer (CHV). The statistically different variables between the study groups are, thus, variables of interest as possible regressors in the regression analyses.

In the entire sample (n = 360), the caregivers' ages averaged at 36(±12) years. However, the IT (n = 77) group was, on average, significantly younger than the rest of the groups. Perumal et al. (2013) observed that the age of antenatal mothers is positively related to their knowledge of and attitude towards child health and nutrition. Arguably, the level of an individual's KAP about a food crop may be related to their experience in farming and family healthcare, which could be related to their ages.

Table 3: Distribution of the Socio-Demographic Variables across the Study Groups

Variables	Total Sample (n = 360)	PT (n = 68) Books +Posters + Poems	IT (n = 77) Books +Posters + Poems + SMS	CT (n = 121) SMS only	Control (n = 94) __	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	*p*- values
Child's Age (years)	5.74(1.10)	5.69[a] (1.11)	5.73 [a] (1.12)	5.6 [a] (1.14)	5.94 [a] (1.02)	0.226
Caregiver's Age(years)	36.01(12.12)	35.66[a] (11.27)	31.47 [b](9.17)	37.10[a](13.02)	38.56[a] (12.76)	**0.001*** **
Caregiver's Education level (years)	7.20 (2.73)	7.01 [a] (2.49)	7.64 [a] (1.94)	7.36 [a] (2.75)	6.77 [a] (3.34)	0.202
Household Size (scale)	6.37 (2.11)	6.63 [a] (2.08)	6.12 [a] (1.82)	6.17 [a] (1.95)	6.64 [a] (2.51)	0.188
HH's Monthly Expenditure ('000Kshs.)	71.39(75.92)	68.98[b] (59.70)	51.24[b](35.21)	67.91[b](75.41)	94.12[a](102.25)	**0.003*** **
Distance to CHV (walking minutes)	15.21(15.77)	9.56 [a] (12.27)	13.81[b](11.51)	18.53[a](17.03)	16.17[a] (18.12)	**0.002*** **
OFSP farm size in 1st Season (m^2)	41.53(52.19)	44.89[ab](55.61)	37.48[b](54.45)	35.94[a](41.51)	44.25 [a] (61.17)	0.056*
Caregiver's Sex (% female)	89	93 [a]	91 [a]	88 [a]	86 [a]	0.580
Households with under-5-year olds (%)	76	74[a]	79[a]	78[a]	73[a]	0.605
Household head's Sex (% female)	17	16 [a]	12 [a]	19 [a]	17 [a]	0.926
Married (yes/otherwise) (% married)	83	82 [a]	87 [a]	80 [a]	84 [a]	0.646
Member of a Farmer Group (0/1) %	32	29 [a]	35 [a]	29[a]	36[a]	0.615
HH grew white/ yellow SP (%)	67	60 [a]	65 [a]	69 [a]	72 [a]	0.411
Grew OFSP in 1st Season (%)	53	57 [a]	47[ab]	31[b]	81 [c]	**0.000*** **

Notes: 1). The last column displays results (p-values) for two-way ANOVA and Kruskal-Wallis tests for differences between the four study groups. 2). * $p<0.10$ ** $p<0.05$ *** $p<0.01$ 3). Superscript letters, along the rows, present results for the pairwise tests of differences in means between 2 study groups after the Bonferroni correction method for multiple pairwise comparisons of sample means. Matching superscripts, ***aa*** or ***bb***, imply no significant differences between the study groups by the given variable, while non-matching superscripts, ***ab***, imply otherwise.

As expected, female caregivers dominated (with 89 percent) the study, with a majority of them being the mothers of the preschoolers. This was expected given that sweetpotato is traditionally regarded as a woman's crop, and women tend to have more influence on the children's food preparation than their male counterparts (Low et al., 2017; Opiyo et al., 2010).

Only a third of the entire sample engaged in farming groups. This finding points to the limited farmer-based avenues for sharing knowledge about different production and nutrition improvement technologies on OFSP and other nutrient-rich food crops. However, they reported an average travel time of 15 walking minutes from their homes to the closest community health volunteers (CHVs). Okello et al. (2019) document how CHVs have previously been engaged by agriculture-nutrition sensitive projects to promote OFSP. However, the current study area had not been reached with such projects.

Additionally, the ECD centers proved to be a good avenue for identifying households with VAD high-risk groups. Indeed, 76 percent and 75 percent of the households had under-five-year-old children and female caregivers of reproductive ages (15 – 49 years), respectively. In the latter case, the remaining quarter of the households had caregivers who form an active social environment to the children (the fathers, grandmothers, and aunts) and should equally be actively integrated into agriculture-nutrition promotion interventions for optimal success (Mutiso et al., 2018).

3.4.3 Distribution of KAP Scores across Study Groups and Time

As demonstrated in Table 4, only caregivers' practices relating to OFSP significantly differed across the study groups at both the baseline and follow-up levels. The OFSP consumption and Vitamin A knowledge only differed between the study groups at follow-up levels, while the

Table 4: Mean Scores of Caregivers KAP Scores Before and After the Intervention across the Study Groups

	PT(n = 68) Mean (SD)	**IT (n = 77) Mean (SD)**	**CT(n = 121) Mean (SD)**	**Control(n = 94) Mean (SD)**	***p*-value^{K}**
Production knowledge (B)	0.661[a] (0.188)	0.656[a] (0.188)	0.671[a] (0.179)	0.670[a] (0.182)	0.912
Production knowledge (A)	0.673[ab] (0.176)	0.743[a] (0.131)	0.704[ab] (0.153)	0.684[b] (0.162)	0.073
***p*-value†**	0.608	**0.000**	0.201	0.619	
Consumption knowledge (B)	0.922[a] (0.167)	0.929[a] (0.129)	0.946[a] (0.119)	0.938[a] (0.137)	0.724
Consumption knowledge (A)	0.966[a] (0.106)	0.971[a] (0.081)	0.958[a] (0.094)	0.916[b] (0.130)	**0.001**
***p*-value†**	0.116	**0.035**	0.396	0.142	
Vitamin A knowledge (B)	0.629[a] (0.330)	0.647[a] (0.305)	0.652[a] (0.304)	0.687[a] (0.291)	0.625
Vitamin A knowledge (A)	0.872[ab] (0.206)	0.887[a] (0.194)	0.861[ab] (0.185)	0.805[b] (0.289)	**0.024**
***p*-value†**	**0.000**	**0.000**	**0.000**	**0.000**	
Attitude towards OFSP (B)	0.609[a] (0.110)	0.623[a] (0.092)	0.636[a] (0.109)	0.617[a] (0.109)	0.350
Attitude towards OFSP (A)	0.690[a] (0.111)	0.683[a] (0.111)	0.699[a] (0.124)	0.667[a] (0.103)	0.130
***p*-value†**	**0.000**	**0.000**	**0.000**	**0.002**	
Practices around OFSP (B)	0.286[ab] (0.162)	0.273[b] (0.180)	0.247[b] (0.149)	0.352[a] (0.212)	**0.003**
Practices around OFSP (A)	0.325[ab] (0.231)	0.302[b] (0.220)	0.256[b] (0.159)	0.351[a] (0.164)	**0.000**
***p*-value†**	0.326	0.320	0.934	0.616	

Notes: 1). KAP score values range from 0 to 1. 2). (B) = Before intervention and (A) = After intervention. 3).^{K}*p*-values from Kruskal-Wallis H tests for differences between the four study groups. 4) † *p*-values from Wilcoxon's signed-rank tests for differences within groups (differences in mean KAP scores between before and after intervention) 5). Bold *p*-values imply statistically significant differences at a 5 percent level of significance. 6). Matching superscripts, ***aa*** or ***bb***, imply no significant differences between the study groups by the given variable, while non-matching superscripts, ***ab***, imply otherwise.

Source: Survey data (2018)

product knowledge and attitude constructs had no statistically significant differences at either the baseline or follow-up levels. Overall, all the study groups had significant improvements in their vitamin A knowledge and attitude towards OFSP after the intervention period ($P<0.05$).

However, only the caregivers in the IT recorded a significant increase in their OFSP production and consumption knowledge. None of the study groups recorded a statistically significant improvement in their level of practice regarding OFSP. This could be because of the relatively short period of the study that did not provide sufficient time for the participating caregivers to start implementing what they have learned about OFSP.

Figure 4 below illustrates how the treatment groups scored on the different KAP constructs before and after the intervention. At baseline, the caregivers' recorded a good mean score (>0.8) in only the OFSP consumption knowledge construct; average mean scores (slightly above 0.6) in the production knowledge, vitamin A knowledge, and attitude constructs; and poor mean scores (<0.5) in the practices towards OFSP construct. The good consumption knowledge scores at baseline can be attributed to the caregivers' participation in the OFSP cooking demonstration sessions before the launch of the interventions. Ribeiro et al. (2015) noted that cooking styles have varied effects on the bio-accessibility of beta-carotene in pro-vitamin A rich foods. Besides reinforcing knowledge on appropriate cooking methods, cooking demos are also intended to ensure cultural acceptability of the food in the diets. Also, the poor performance by the caregivers on the practice construct can partly be attributed to the fact that this was the first time that they engaged with the crop and hard relatively short time to implement the practices, as earlier argued.

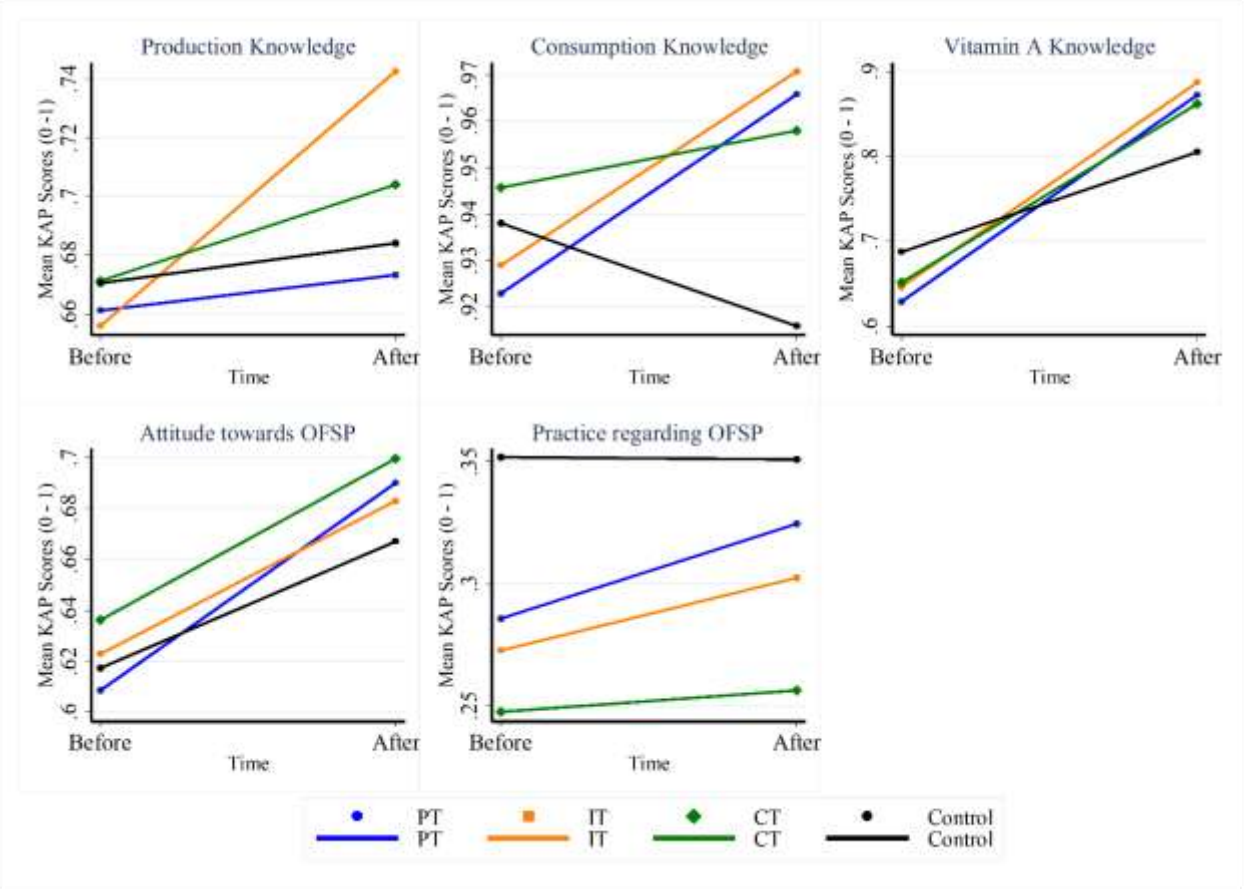

Figure 4: Trends of Mean KAP Scores Before and After the Intervention by the Study Groups

Source: Survey data (2018).

Post-intervention, there were increased mean scores in the production knowledge constructs across the study groups. However, the changes in the IT treatment group were more significant than for the rest of the groups. Interestingly, while all the treatment groups recorded improvements in their consumption knowledge mean scores, the control group scores dropped. This could imply the possibility of erosion of knowledge of the nutritious crops in the absence of continuous nutrition educations and other awareness enhancement interventions. Also, all the groups recorded increases in their vitamin A knowledge and attitudes toward OFSP. Overall, the

variation in the behavior of the treatment groups against the control groups suggests the need to further systematically explore how the different intervention worked in follow up studies.

3.4.4 Mean Changes in KAP Scores

Table 5 below presents the distribution of the mean changes in the respective KAP scores across the study groups. The results show that, over time, an individual's knowledge, attitude, and practices towards OFSP are destined to change. However, a positive change is desirable to leverage the pathways to improved nutritional status among households targeted by agriculture-nutrition sensitive interventions. The fact that all the intervention groups recorded positive mean changes in the KAP scores, while the control groups recorded a mix of negative and positive mean changes, is especially interesting.

The Spearman correlation results indicate that, overall, change in the KAP scores was negatively associated with an individual's assignment into a control group (Spearman's rho = -0.143, p = 0.005), and positively associated with their assignment into the IT group (Spearman's rho = 0.129, p = 0.015). In terms of the magnitude of change, only the mean changes in OFSP consumption knowledge and vitamin A knowledge scores were significantly higher in the PT and IT groups than in the control group. However, it is imperative to acknowledge that the associations do not sufficiently imply causations. Thus, the effectiveness of these reported relationships in informing substantive policy recommendations is limited. Therefore, the cause-and-effects are explored in section 3.4.5 below.

Table 5: Mean Changes in Caregivers' KAP Scores (Follow-up minus Baseline Scores) by Study Groups

	Study Groups				
Variable	**PT (n = 68) Mean (SD)**	**IT (n = 77) Mean (SD)**	**CT (n = 121) Mean (SD)**	**Control (n = 94) Mean (SD)**	***p*-value**
Δ in Production Knowledge	0.011[a] (0.254)	0.098[a] (0.184)	0.032[a] (0.235)	0.014[a] (0.235)	0.106
Δ in Consumption Knowledge	0.038[a] (0.196)	0.041[a] (0.155)	0.015[ab] (0.152)	-0.021[b] (0.2)	**0.040****
Δ in Vitamin A Knowledge	0.243[ab] (0.337)	0.240[a] (0.347)	0.230[ab] (0.319)	0.118[b] 0.373)	**0.080***
Δ in Attitude Level	0.081[a] (0.154)	0.060[a] (0.145)	0.063[a] (0.144)	0.050[a] (0.140)	0.535
Δ in Practice Level	0.039[a] (0.268)	0.030[a] (0.233)	0.009[a] (0.207)	-0.001[a] (0.239)	0.816

Notes: 1). Change in KAP score values ranged from -1 to 1. 2). *p* -values adjusted using the Bonferroni correction method for multiple pairwise comparisons of sample means. Matching superscripts, ***aa*** or ***bb***, imply no significant differences between the pair of study groups by the given variable, while non-matching superscripts, ***ab***, imply otherwise. * $p<0.10$ ** $p<0.05$ *** $p<0.01$

3.4.5 Treatment Effects

Table 6 presents the estimates of the generalized linear models of each of the mean changes in KAP scores. After controlling for the differences in socio-demographics and the respective baseline KAP scores, nutrition education through the PT approach significantly improved the caregivers' knowledge on consumption OFSP and vitamin A. The IT approach, on the other hand, improved both the caregivers' OFSP production knowledge, consumption knowledge and the vitamin A knowledge. Similarly, the CT approach improved the caregivers' consumption knowledge, vitamin A knowledge and attitude towards OFSP. None of the approaches caused statistically significant improvements in the caregivers' practice relating to OFSP production and consumption.

Table 6: GLM Estimates for Mean Change in OFSP Knowledge, Attitude, and Practices among the Caregivers of Preschool Children in the Study Sample†

Change in scores	Production Knowledge	Consumption Knowledge	Vitamin A Knowledge	Attitude	Practices
Treatment variables					
Preschooler Treatment (PT)	-0.011	**0.056*****	**0.096***	0.025	0.011
	(-0.64)	(4.24)	(1.66)	(1.24)	(0.31)
Integrated Treatment (IT)	**0.054****	**0.068*****	**0.106***	0.012	0.007
	(2.54)	(5.55)	(1.75)	(0.95)	(0.14)
Caregiver Treatment (CT)	0.021	**0.063*****	**0.094***	**0.038****	-0.011
	(1.24)	(11.51)	(1.84)	(2.67)	(-0.33)
Controls†					
Production Knowledge at baseline (kp0)	**-0.929*****	-	-	-	-
	(-22.57)				
Consumption Knowledge at baseline (kc0)	-	**-1.037*****	-	-	-
		(-35.96)			
Vitamin A Knowledge at baseline (VA0)	-	-	**-0.871*****	-	-
			(-17.37)		
Attitude towards OFSP at baseline (att0)	-	-	-	**-0.871*****	-
				(-11.58)	
Practice level at baseline (pract0)	-0.043	**0.075****	**0.235*****	0.029	**-0.898*****
	(-0.84)	(2.59)	(5.21)	(0.68)	(-19.25)
Distance to CHV (*square root)*	0.002	-0.005	0.003	-0.001	-0.004
	(0.08)	(-1.59)	(0.50)	(-0.34)	(-1.47)
Grew OFSP to maturity (1st season)	0.017	0.016	0.025*	0.018	**0.159*****
	(0.95)	(1.25)	(1.86)	(1.23)	(6.19)
Child Dietary Diversity Score	-0.008	0.001	-0.004	0.0005	-0.002
	(-1.16)	(0.15)	(-0.53)	(0.08)	(-0.28)
Aware of vine multiplier in the village	0.040	-0.0342	0.00393	0.0200	0.079
	(1.49)	(-1.18)	(0.11)	(0.95)	(1.52)
Distance to market (*square root)*	0.003	**0.005****	-0.0025	0.0039	-0.002
	(0.63)	(2.10)	(-0.40)	(1.28)	(-0.50)
Household Food Insecurity (Access) Scale	-0.001	-0.000	0.002	**-0.003****	0.000
	(-0.43)	(-0.04)	(0.88)	(-2.98)	(0.03)
Caregiver's Age (Years)	-0.031	-0.179	0.679*	0.277	-0.058
	(-0.09)	(-0.81)	(1.83)	(1.21)	(-0.16)
Constant	**0.668*****	**0.929*****	**0.494*****	**0.536*****	**0.219****
	(11.25)	(12.55)	(3.83)	(7.95)	(2.88)
Observations	355	349	360	360	360
Wald Chi^2	1484.2	6112.0	12202.8	792.8	4995.2
p-value > $\lvert\chi^2\rvert$	<0.001	<0.001	0.000	<0.001	0.000
R^2	0.558	0.668	0.626	0.418	0.476

Notes: *t* statistics in parentheses; wild cluster bootstrap-t procedure used to adjust the p-values

(not shown); $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.001$

† The five models testing for the effect of intervention assignments were adjusted to control for the baseline scores for the respective KAP categories and the variables which were found significantly different between the study groups at baseline.

3.4.5.1 Multicollinearity

A post-estimation test was done to inspect likely cases of multicollinearity in the variables used to estimate the changes in the KAP scores. A variance-inflation factor (VIF) test was done following a linear regressions of the main model specification presented in Table 6. The VIF score of 1.14, against a threshold of 5, indicated that there were no cases of multicollinearity in the given GLM estimations.

3.5 Discussion

The findings are similar to those of a study in Uganda (Nabugoomu et al., 2015), which showed that nutrition education improved the caregivers' knowledge related to vitamin A and OFSP as a source of vitamin A and their attitude towards child healthcare practices. However, the study focused on an urban and peri-urban farming setting and had a different nutrition education approach.

The performance of the interventions suggests significant improvements in our measured dimensions of nutritional knowledge relating to OFSP if a multi-channel nutrition education approach is used (i.e., the IT approach). Comparatively, the CT approach performed better than the PT approach in improving the knowledge constructs. Given the fact that, overall, the entire sample had very poor attitude scores, a particular focus on improving their attitude scores is more critical. The results show that the phone-mediated texts are a relatively more effective means of influencing the caregivers' attitude towards OFSP. Further, as mediators of behavior change, improvements in both knowledge and attitude may have trickle-down effects on the

availability of the OFSP in the household menus and intake of vitamin A. These results are broadly in line with the propositions of the social cognitive theory and findings of Mutiso (2017), which show evidence for the use of a multicomponent approach when intervening with children to enhance the effectiveness of information reception, retention, and transfer to others including caregivers.

The daily transmission of the messages to the households via phone-based text messages enhanced the response of caregivers. Indeed, the CT treatment had a greater effect on the attitude of the caregivers but not of the control group. Further, with the positive results of phone-mediated messages on improving the caregivers' overall knowledge and attitude towards OFSP in the CT approach, the study underscores the role ICT can play in influencing knowledge, attitude and practices relating to biofortified crops, their acceptance and utilization in the rural households. The finding also contributes to the literature on the effectiveness of ICT-integrated nutrition education in improving the diets of rural farming households (Webb, 2013). The results also show that the CT approach significantly increased consumption and vitamin A knowledge and also attitude but had no effect on practice and also production knowledge. On the other hand, the preschooler targeting was only effective in improving knowledge. The latter finding fails to reject the hypothesis that targeting preschoolers alone with nutrition education does not improve the caregivers' level of practice regarding OFSP. A possible reason is because preschoolers are not involved in cooking and production practices; hence their influence is limited to providing information awareness.

3.6 Conclusion

The study finds that participants who received all the interventions had significantly higher improvements in knowledge and attitude scores than their counterparts. Given the findings, the

study concludes that multi-channel oriented nutrition education involving preschoolers and phone-mediated text messages to the caregivers is an effective strategy of influencing caregivers KAP. Further, interventions targeting preschoolers only are more effective in improving knowledge of caregivers, while those that specifically target caregivers through mobile-phone mediated messaging are effective on caregivers' knowledge of and attitude towards OFSP.

These findings imply that integration of nutrition education messages on the learning materials of children enrolled in the ECD centers/institutions by government and other education providers can be leveraged to effectively deliver agriculture-nutrition education and extension relating nutrient-rich biofortified foods to rural households. They also suggest that preschoolers and their learning materials can sufficiently nudge the caregivers and influence their knowledge and or attitude towards the OFSP.

The findings also imply that mobile phone-mediated text messaging can be used effectively to influence the behavior of caregivers as related to knowledge and attitude towards OFSP. The advantages of using mobile-phone mediated education and extension over face-to-face have been widely documented in research and development literature and include, among others, the low-cost of intervention. However, this approach can work better where targeted households are digitally literate and know how to operate text messaging functions of mobile phones.

CHAPTER FOUR: EFFECTS OF INTEGRATED NUTRITION EDUCATION INTERVENTIONS ON THE LEVEL OF REPLANTING OFSP AMONG CAREGIVERS

4.1 Abstract

Recent studies have confirmed that biofortified foods can contribute to the reduction of malnutrition and are readily accepted by young children. Contemporary projects are increasingly using elementary schools to target households for sustainable influence on their adoption of OFSP. The objective of this chapter was to assess the effects of integrated nutrition education approaches, targeting preschoolers and their caregivers, on retention of OFSP in farms. The analysis in this chapter involves the same respondents of the same sample size and exposed to the same randomized controlled trial design and interventions described in section 3.3.1 through 3.3.4 above. This chapter analyzes the household-level survey data collected from 360 caregivers before and after the intervention. The outcome of interest was whether a caregiver replanted OFSP in their farms in the second season after the lapse of the free vines dissemination project. The analysis involved a binary logit model and special regressor method to estimate the intention-to-treat and treatment-on-the-treated effects of the interventions, respectively. The results show that only the multi-channeled nutrition education approach had significant effects on the caregivers' likelihood (16.7 percent – 24.3 percent, p-value<0.00) to retain OFSP in their farms. The findings imply that multi-channeled agriculture-nutrition education interventions through ECDs can be effective in ensuring sustainable adoption of OFSP.

4.2 Introduction

Unlike industrial fortification and supplementation approaches in the pathways to VAD eradication, bio-fortification is more sustainable because its potential scale-up is not exclusively dependent on continued financial injections by the government or external development partners

in the value chain (Bouis et al., 2018). OFSP, for instance, is vegetatively propagated, and the rural sweetpotato farmers have a traditional culture of vine sharing. However, with the growth of its commercialization campaigns, there have been reportedly low levels of vine sharing for free.

The decentralized vine multipliers (DVMs) have played a significant role in ensuring the continued supply and existence of OFSP in farms in areas where they operate. Otherwise, research has shown that OFSP would have been extinct in many of the villages where it had been introduced before (Jenkins et al., 2018). Farmers have a significant challenge with conserving the vines and retaining the crop in subsequent planting seasons, which is critical for the continued supply of the roots. Instead, they have persistently called for free vine handouts in subsequent planting seasons from friends owing to the good culture of vine sharing, and from the development organizations. Therefore, despite the considerable potential of OFSP to change the face of nutrition and food security status of the society, sustainability of the technology among farmers is still under question. Recent studies have, thus, recommended encouragement of the communities to make efforts to conserve the vines for future growth (Jenkins et al., 2018; Bouis et al., 2013).

Given the importance of OFSP in the fight against VAD, several projects in SSA have focused on promoting its adoption and consumption through schools, especially in Uganda, Nigeria and Ethiopia (Mwanga and Ssemakula, 2011; Phorbee et al., 2015; Kwikiriza et al., 2015). In most instances, the promotion of OFSP has involved the development of school gardens and the transfer of OFSP vines to the households. It has also involved the integration of OFSP in the school feeding programs. However, there is weak evidence of the sustainability of these delivery approaches regarding the retention of the planting materials at household levels (Jenkins et al.,

2018). In the context of this study, retention refers to the capability of the farmer to conserve the vines from previous production and replant in the subsequent season.

4.3 Objective and Methodology

The objective of this chapter was to assess the effects of multi-channel nutrition education approaches, involving school children and caregivers' mobile phones, on the replanting of OFSP among the caregivers after the initial distribution of free vines. The quantitative analysis approach taken is discussed below.

The dependent variable, whether or not the caregiver replants OFSP, was measured once – in the follow-up survey. Thus, the data were analyzed as cross-sectional data. Due to the binary nature of the outcome variable, *D*, the study uses the binomial logit specification in Equation 4 below to estimate the probability of a person deciding to replant OFSP given a set of regressors.

$$Pr(D_{iv}) = expit\left(\beta_0 + \beta_1 PT_{iv} + \beta_2 IT_{iv} + \beta_3 CT_{iv} + \beta_4 Y_{v(t-1)b} + X_{iv}\beta_5 + \lambda_b + \epsilon_{iv}\right) \quad \ldots\ldots (4)$$

where *D* is the dependent variable (retention of OFSP), and *PT*, *IT*, and *CT* are the indicators for assignment of treatments with the control group having been taken as the reference group.

The parameter estimates of the regressors are given by $\beta_1 \ldots \beta_5$. The random error term, ϵ_{iv}, is adjusted at the village cluster levels. In this case, $Y_{v(t-1)b}$ refers to the area of the OFSP garden planted in the first season at baseline; X_{iv} is a vector of the child, caregiver and household characteristics; and λ_b is a set of sub-county fixed effects since the randomization was clustered at village levels. Further, the average marginal effects of treatment between the treatment groups and the control group were estimated. Other exogenous variables included in the model were drawn from the literature on factors affecting OFSP adoption (Kaguongo et al., 2012; Mazuze, 2007; Okello et al., 2019).

The ‘treatment assignment variables’ (PT, IT, and CT) were used to estimate the intention-to-treat (ITT) effects in an adjusted binary logit model in Equation 4. The respective treatment reception variables (RPT, RIT, and RCT) were measured as dummies and noted as endogenous (instrumented by the respective treatment assignment variables - PT, IT and CT). These were used to estimate the treatment-on-the-treated (TOT) effects. Further, Equation 4 above was adjusted and estimated using the Lewbel’s (2000) Special Regressor Method (SRM), which unlike IVProbit and Tobit models, allow for discrete endogenous explanatory variables (EEVs) and provides a single estimation method irrespective of the nature of the endogenous regressors (Baum et al., 2012; Bontemps and Nauges, 2015; Dong and Lewbel, 2015; Lewbel et al., 2012). The SRM model was executed with the guidance of Baum’s (2012) “*sspecialreg”* module in Stata version 14.2.

4.4 Results

4.4.1 OFSP Production

Among those who planted the crop in the first season, 62 percent retained the planting material and planted in the second season (see Figure 5). Fewer farmers retained the crop in the control group relative to those in the treatment groups. About 80 percent of the caregivers in the IT group planted the OFSP in the first season and retained it in the second season, while only half of the caregivers in the CT group did so. Further, the average sizes of the OFSP plots also differed significantly across the study groups in both seasons.

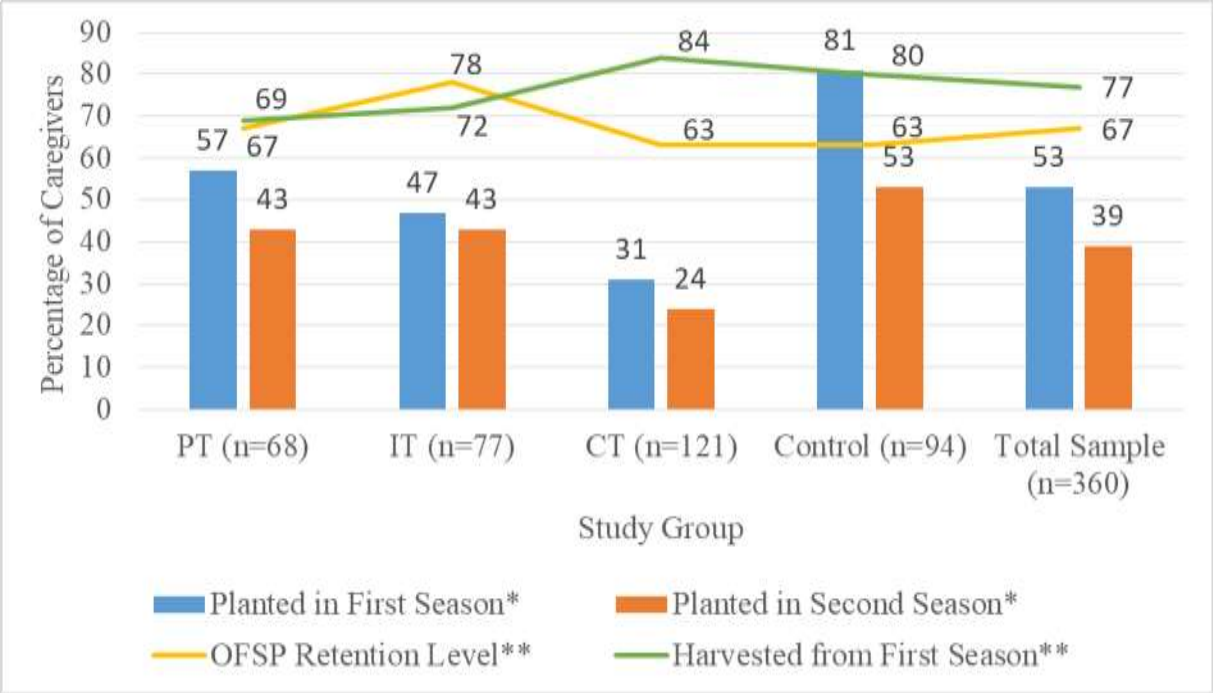

Figure 5: Caregivers' Engagement with OFSP across the Study Groups

Note: *n = total sample size of the study group as in the parentheses. ** n = total number of those who planted OFSP in the 1st season.

Source: Survey data (2018).

Interestingly, about 6 percent of respondents who failed to harvest their OFSP crops in the first season had planted the crop in the second season. These were exclusively IT group members. The low rate of diffusion of the technology was expected given the fact that the vines were distributed in small amounts - each farmer receiving 200 cuttings of 30 centimeters each. Further, the average sizes of the OFSP plots also differed significantly across the study groups in both seasons.

4.4.2 Participation in the Study Interventions

Figure 6 presents data on caregiver's participation in the different intervention groups. The results show that 7 percent of caregivers in the control group received the messages designed for the intervention groups and are, therefore, spillovers. Overall, results show that the assignment of a caregiver to a given intervention significantly influenced their exposure to the assigned interventions in comparison to other groups (Pearson Chi^2 (9) = 356.26, *p*-value <0.000).

Also, 76 percent of the caregivers could remember the nutrition information delivered via the mobile-phones, while only 54 percent remembered messages in preschoolers' books. However, all households who were targeted by both approaches attested to have received the nutrition education information from either of the sources.

The mobile phone-mediated messaging has the advantage of conveying messages/information directly to the targeted caregiver than when the messages are conveyed through the preschoolers and their learning materials as in the PT group. Although every member of the CT and IT groups owned a mobile phone, 12 and 24 percent, respectively, indicated that they did not get the mobile-phone-mediated nutrition education information. This could be because they did not see the text message or know how to read it (Okello et al., 2012). Notably, all the caregivers in the IT group indicated that they received nutrition education information from at least one intervention channel. Further, in the same group, the proportion that received messages from both channels was higher.

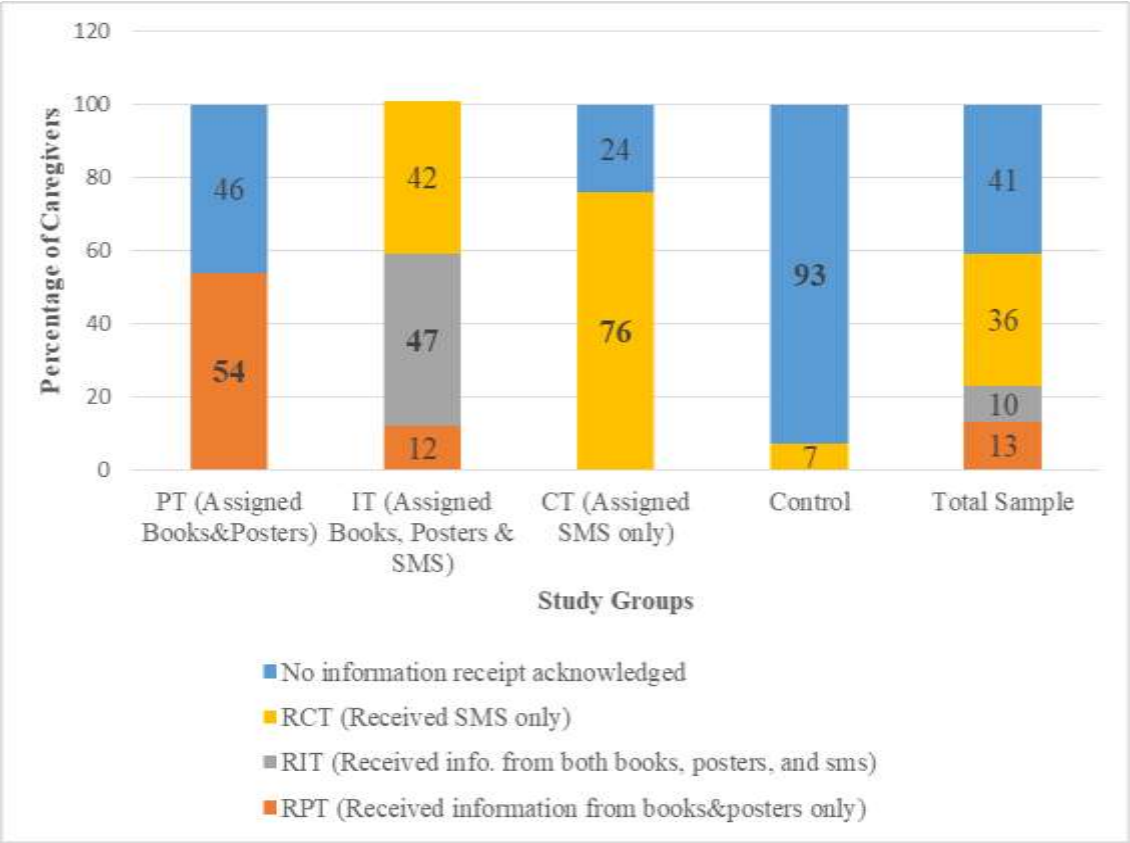

Figure 6: Assignment and Acknowledgment of the Interventions among Caregivers

Source: Survey Data (2018).

4.4.3 Treatment Effects

4.4.3.1 Intention-to-Treat Effects

The estimation results of the binary logit regression of the treatment assignment variables and the control covariates on OFSP retention (a caregiver's decision to replant OFSP in the second season after initial free distribution of vines) are provided in Table 7. The results show that positive and significant effects only exist for assignment into the integrated treatment group. The estimates for single entry point interventions, PT and CT, are not significant. Besides, the CT approach estimate gives a surprising negative sign.

The positive estimate in the IT approach implies that caregivers that got nutrition education information from both the books, posters and poems given to the preschoolers and phone-

mediated messages to the caregiver's mobile phone were more likely to replant OFSP in the second season than their counterparts who did not get such combinations. The marginal effects indicate that the assignment of a household to both preschool and caregiver directed nutrition education increased the likelihood of planting OFSP by 16.7 percent, other factors constant.

Table 7: Logit Regression Results - Average Marginal Effects Estimates of Nutrition Education Interventions and Other Covariates on Retention of OFSP

			Average marginal effects	
Dependent variable- RETAIN OFSP	Coefficients	*p*-value	dy/dx	*p*-value
PT	0.321	0.591	0.064	0.586
IT	0.841***	**0.001**	0.167***	**0.001**
CT	0.128	0.635	0.026	0.634
Household Size (*log*)	0.921*	**0.057**	0.183*	**0.052**
Grew White and Yellow-Fleshed SP	0.944***	**0.008**	0.188***	**0.004**
Caregiver's Knowledge level on OFSP (*squared*)	1.669*	**0.092**	0.332*	**0.080**
Caregiver's Attitude level on OFSP (*squared*)	-0.546	0.463	-0.109	0.458
Member of a farmer group	0.403	0.246	0.080	0.241
Constant	-1.129	0.125		
Test 1: H_0: PT=IT		0.384		
Test 2: H_0: PT=CT		0.752		
Test 3. H_0: IT=CT		**0.013**		
Test 4: H_0: PT= IT=CT=0		**0.043**		
Observations (*who planted OFSP in 1st season*)	189			
Wald $Chi^2(8)$	33.890			
Prob > Chi^2	0.000			
Pseudo R^2	0.083			

Note: The sample contains only those who planted OFSP in the first season. Standard errors (not presented) were adjusted to clusters at ECD center levels.

PT = Assigned Preschooler-oriented Treatments; **IT** = Assigned Integrated Treatment; **CT** = Assigned Caregiver-oriented Treatment.

Source: Survey Data (2018).

However, a Wald test for joint restriction for the three treatments gave significant statistics, a *p*-value of 0.016 indicating that, collectively, the complementary nutrition education interventions have a relatively strong and significant effect on the likelihood of caregivers to retain the OFSP.

4.4.3.2 Treatment-on-the-Treated Effects

The average treatment-on-the-treated effects were estimated using the SRM. The endogenous variables were exactly identified; Z and X^e have three parameters on both sides of the "first-stage equation." Further, the Durbin Wu-Hausman test for endogeneity, with the null hypothesis that the instruments are exogenous yielded $Chi^2(3) = -36.1199$ and *p*-value = 1.0000. It shows that all the instruments are indeed exogenous. Education, income, and child's age were tested as instrumental variables that determine whether or not a caregiver acknowledges the reception of the assigned treatment. However, the results of the Sargan-Hansen test (Sargan $Chi^2 = 98.6623$; *p*-value<0.000) found no evidence of over-identification. The standard errors were also adjusted to account for possible heteroscedasticity in the clusters.

As presented in Table 8, the SRM regression results show that reception of nutrition education through the IT approach had a positive and significant effect on the caregivers' decision to retain the OFSP. Conversely, reception of information channeled through the preschoolers alone (RPT) or the caregivers alone (RCT) did not give any significant effects. Estimates of the average marginal effect for RIT suggest that other factors held constant, households where both the caregiver and the preschooler received the nutrition education information, were 24.3 percent more likely to replant the OFSP in the second season. As was the case with the ITT, a Wald joint exclusion restriction test yielded a *p*-value of 0.065, which indicates that channeling nutrition education through the three approaches had a significant effect on the caregivers' likelihood to replant OFSP in the second season.

Table 8: SRM Results - Marginal Effect Estimates of Nutrition Education Interventions and other Covariates on Retention of OFSP

			Marginal effects at means[a]	
Dependent Variable- Retain OFSP	Coefficients	*p*-value	dy/dx	*p*-value
RPT	0.269	0.341	0.088	0.341
RIT	0.744***	**0.007**	0.243***	**0.007**
RCT	-0.093	0.642	-0.030	0.642
Distance to CHV (*square-root*)	0.061**	**0.040**	0.020**	**0.040**
Size of OFSP plot (*square-root*)	0.045***	**0.008**	0.015***	**0.008**
Harvested OFSP in last season	0.274**	**0.028**	0.089**	**0.028**
Caregiver is Married	-0.174	0.287	-0.057	0.287
DVM is nearby	-0.405*	0.054	-0.132*	0.054
Caregiver's Knowledge of OFSP (*squared*)	0.315	0.325	0.103	0.325
Caregiver's Attitude towards OFSP (*squared*)	-0.116	0.620	-0.038	0.620
Household Monthly Expenditure (*logged*)	-0.104*	0.080	-0.034*	0.080
Preschooler's Age (*Years*)	-1.594	0.662	-0.521	0.662
Household Size (*log*)- *the special regressor*			0.327	
Constant	0.343	0.552	0.112	0.552
Test 1. H_0: RPT=RIT		0.200		
Test 2. H_0: RPT=RCT		0.198		
Test 3. H_0: RIT=RCT		**0.022**		
Test 4. H_0: RPT=RIT=RCT		**0.065**		
Observations (180 trimmed)	180			
Wald Chi^2	23.84			
Prob> Chi^2	0.021			
Root MSE	0.693			

Notes: 1). The sample contains only those who planted OFSP in the first season. 2). Standard errors (not presented) were adjusted to clusters at ECD center levels. 3). [a]Marginal effects estimated using Average Index Function (AIF) (Baum, 2012). **RPT** = Received Preschooler-oriented Treatment; **RIT** = Received Integrated Treatment; **RCT** = Received Caregiver-oriented Treatment.

*p<0.10, **p<0.05, ***p<0.01

Source: Survey Data (2018).

A comparison of the estimates of the ITT and TOT from the IT approach yields some interesting insights. The variation implies that there is a significant difference in results achieved by the provision of nutrition education initiatives and ensuring that the targeted population receives and acknowledges the issued messages. The latter has higher positive effects than the former.

4.5 Discussion

In this chapter, the immediate effects of the nutrition education interventions through single and multi-channel approaches on the early adoption of OFSP through the ECD centers was assessed.

The study found that at least three-quarters of households reached through ECD platforms are households with under-5-year olds and reproductive-age women. Homa Bay county government reports that the county has 1183 ECD centers, 905 primary schools, and 260 health facilities. ECD centers provide a relatively broader avenue for reaching the target population of nutrition security programs in the rural setting of the county. The ECD institution, therefore, is a potentially considerable platform for the introduction and execution of agriculture-nutrition sensitive interventions to make nutritious foods more accessible to everyone, especially the micro-nutrient deficiency vulnerable groups.

Overall, the interventions as designed and assigned reached slightly less than three-quarters of the caregivers in the treatment arms. As for the single-channel approaches, the rate of intervention reception was higher with the CT than the PT approach. The multi-channel approach (IT) resulted in a hundred percent rate of intervention reception. This means that the preschoolers' channel conveys information less directly to the intended caregivers than the mobile phone channel. However, having both approaches ensures that all the caregivers receive the intervention from at least one of the two channels.

Unlike the IT approach, the PT and CT approaches failed to induce significant intention-to-treat effects on retention of the OFSP among the caregivers. This confirms the hypothesis that single-channel nutrition education approaches do not improve the probability of the caregivers to retain OFSP in their farms after the initial dissemination of free planting materials. However, the hypothesis that the multi-channel nutrition education approach does not improve the probability of the caregivers to retain OFSP in their farms after the initial dissemination of free planting materials was rejected.

Comparing the estimates of the intention-to-treat and the treatment-on-the-treated effects of the IT approach gives exciting insights. The variation in the magnitude of the estimates implies that there is a significant difference in the effects of offering agri-nutrition education intervention and the effects of intervention participation. Mechanisms that ensure that the targeted caregivers receive the assigned nutrition education through multiple channels improve the likelihood of replanting OFSP by 24.3 percent. This is, definitely, the effects of caregivers' response to nutrition education through both channels simultaneously.

In the context of sustainable adoption of agri-nutrition sensitive technologies, this study provides a set of lessons that may be valuable for future studies and projects. Our results show that the success of a nutrition education initiative relies on whether or not it is channeled through multiple approaches. Targeting both preschool children and their caregivers (predominantly their mothers) with nutrition education information ensures retention of the crop on the farms of the target households. The level of impact of the same depends on the extent to which the targeted population takes-up the intervention per design. Although a majority acknowledged receiving the interventions, ensuring that all the targeted respondents receive the interventions is worth considering to maximize their efficiency when up-scaling such interventions.

4.6 Conclusion

Based on the findings, the study concludes that it's practically possible to nudge rural farming households to retain biofortified technologies, particularly OFSP, through complementary nutrition education involving preschool children and mobile phone-mediated messaging platforms. Accordingly, continued retention and production of the crop will enhance the availability of the nutrient-rich food on the menus of the malnutrition high-risk groups. The study also concludes that ensuring the interventions reach all the targets is an important factor in ensuring the success of their intended purpose. Integrated complementary nutrition education on biofortified crops is important in the pathways to ensuring sustainable adoption these nutritious foods among the rural farming households.

CHAPTER FIVE: EFFECTS OF INTEGRATED NUTRITION EDUCATION APPROACHES ON THE CONSUMPTION OF OFSP AMONG PRESCHOOLERS

5.1 Abstract

Biofortified staples have been promoted widely in Africa and Asia as a sustainable way to address the undernutrition problem. Progress in ensuring continuous consumption of the vitamin-A-biofortified OFSP is relatively slow. This highlights the challenge faced by existing scale-up programs in instilling nutritional value of the technology at the desired pace. Accordingly, the identification of more testable, scalable, and evidence-based accelerators of consumption of nutritious foods has been of considerable interest in recent studies. The objective of this study was to assess the effect of nutrition education to preschool children and their caregivers on their consumption of OFSP. This chapter uses a different -but related sample of 373 preschooler-caregiver pairs who had the baseline household-level surveys, and their preschoolers registered their consumption data with the class teachers. However, the sample was recruited as prior described in section 3.3.1. Consumption data were collected from preschoolers using adjusted child dietary diversity registers. The class teachers sought 24-hour recalls of meals consumed by the preschoolers on every school day. Data were analyzed using a zero-inflated Poisson regression model. The results show that while production of the crop enhanced its consumption, a significant proportion of caregivers who failed to produce and harvest OFSP from their farms also fed their children on the same. Being assigned the mobile-phone mediated nutrition education messages and the multi-channeled intervention approach significantly improved the frequency of OFSP consumption among the preschoolers. Based on the findings, the study concludes that, collectively, nutrition education through OFSP-branded preschoolers' learning materials and mobile phone-mediated messages are effective nudges to the caregivers to

continuously feed their preschool children on the OFSP. Contemporary and future agriculture-nutrition education programs should consider early childhood development institutions as effective platforms for ensuring sustainable consumption of nutritious food crops.

5.2 Introduction

Diet-related health challenges are stubbornly rising with the global population growth. Micronutrient deficiencies are reported to be more prevalent in SSA countries; anemia (46-71 percent), VAD among under-five-year-olds (48 percent), iodine deficiency (36 percent), and zinc deficiency (25 percent) (Global Nutrition Report, 2018; FAO et al., 2019). Underlying the deficiencies are unsustainable and inadequate nutrient intakes borne from consumption of nutrient-poor foods and poor diet diversity. Conventional approaches, such as supplementation of vitamins and minerals and fortification of processed food, although effective, have been proven unable to provide a holistic solution to all scenarios. Besides, the persistence of malnutrition supports the case for more concerted efforts to complement the conventional approaches to combating malnutrition. Consequently, more attention has been directed towards improving food system approaches to deliver sustainable, high-quality diets to alleviate the malnutrition problems (Global Panel on Agriculture and Food Systems for Nutrition, 2016; Global Nutrition Report, 2018).

Thanks to Nobel Laureates Marie Adrande, Jan Low and Robert Mwanga, OFSP is now the leading success story of the bio-fortification technology in combating micronutrient deficiencies (The World Food Prize, 2016). Research has shown that regular consumption of 100-125g of OFSP boiled roots induced significant increments in the vitamin A content in the liver of the under-5-year-old children (Bouis and Saltzman, 2017; Greiner, 2017; Holtz et al., 2012; Low et

al., 2017; Neela and Fanta, 2019). Therefore, it is imperative to ensure that dietary diversification campaigns include biofortified crops, for they are part of the collection of the available diversified diets. Besides, the technology fits in the food systems of many developing countries where the rural farming families most often consume food they source from their farms and or immediate vicinity.

However, sweetpotato is more perceived as a food security crop and a secondary staple in Kenya and many SSA countries (Low et al., 2009; Tedesco and Stathers, 2015; Neela and Fanta, 2019). Therefore, the per capita consumption of sweetpotatoes is relatively low compared to such staples like maize and rice. This is despite the continued display of evidence on its exceptional endowment with a rich nutritional composition relative to other local vegetables. According to Neela and Fanta (2019) and Girard et al. (2017), OFSP was ranked top from a dietary point of view, beating all other vegetables in terms of proximate, mineral and βcarotene composition. This scenario argues for the need to streamline OFSP campaigns to focus on ensuring its increased consumption per capita and not just replacing the white and yellow-fleshed varieties with the OFSP in the menus. Besides, the new variety (OFSP) has relatively better environmentally resilient agronomic traits and economic value given the productivity and increased end uses than the traditional landraces – white and yellow fleshed – sweetpotatoes.

Research studies have repeatedly affirmed that due to its sweet taste, most young children will consume OFSP in significant quantities during the harvesting period (Low et al., 2007; Neela and Fanta, 2019). However, it is important to ensure sustained regular intake of vitamin A and other nutritional essentials in the household, especially among the vulnerable group. This study used targeted nutrition education to accompany OFSP introduction campaigns and assess its

potential in enhancing behavioral changes among caregivers of preschool children that leads to increased utilization.

While OFSP promotion campaigns have recommended its daily consumption (Burri 2011), the rates are evidently low in many countries. In most of the reviewed literature, a majority of the sample consumed it in less than three days in the previous seven days (Sakala et al., 2018). Converting OFSP to an individual's dietary habits may also have a ripple effect on its supply factors due to the improved demand, thereby enhancing the food security status of the household.

Previous studies have often concentrated on assessment of the drivers of consumption of OFSP and its role in diet diversification (Hummel et al., 2018; Gelli et al., 2018; Okello et al., 2014). However, the current study assesses the interventions beyond the potential influence on caregivers' decision to feed their preschoolers on OFSP to the frequency of its consumption over time. Notably, a few studies (Hummel et al., 2018; Gelli et al., 2018; Nabugoomu et al., 2015) draw close to a similar premise of reaching the households through the ECD centers. However, the present study adopted a completely different design of intervention by involving the preschoolers as mediators in the pathways to delivering nutrition education information to the caregivers who are the key decision-makers on what the children have for their meals. The current study also integrated the use of mobile phones as a platform for disseminating information and reaching the target in a potentially more efficient manner. Further, the effects of the interventions on food consumption frequency were also assessed in the current study.

5.3 Objective and Methodology

This study aimed to assess the effects of ECD channeled nutrition education approaches involving preschoolers and their caregivers on their OFSP consumption frequency. On the same design as described in Chapter Three, the study used the public-run ECDs as a platform to implement OFSP promotion interventions to the households and experimented single and multi-channel nutrition education approaches involving the preschoolers and their caregivers on the frequency of consumption of OFSP among preschool children. This chapter addresses two objectives: 1) The effects of the nutrition education approaches on the frequency of OFSP consumption among preschoolers; 2) The effects of nutrition education on the likelihood of the preschoolers to consume OFSP at least once in a 5-day week.

It is imperative to note that the interventions (as described in Chapter Three) were issued for thirty days from the second week of September 2018 when it was expected that all the households were harvesting the OFSP, planted in April the same year. Consumption of OFSP was expected during this period and the interventions were complementary to the routines nutrition education issued during vines dissemination and cooking dissemination sessions.

5.3.1 Instruments and Data Collection

Data were collected using two tools; pretested questionnaires administered by trained enumerators and dietary diversity registers marked by class teachers, also trained for the course.

Food frequency questionnaires (FFQs) have been used to measure the frequency of food and food group consumption frequencies in many studies. However, studies have documented its limited reliability due to failures to take care of recall bias and measurement errors owing to the

long recall period (Bell et al., 2019). This study used an adjusted child's dietary diversity (CDD) measurement tool to limit the food consumption recall period to 24 hours instead of 7 days as in the FFQs (Bell et al., 2019). A CDD tool is always constituted of 9 food groups. In this study, the tool was adjusted to including two extra rows that singled out the 'white and yellow-fleshed sweetpotato' and the 'OFSP' foods from the 'cereals and other carbohydrates' and the 'vitamin A vegetables' food groups, respectively. Thus, the modified tool was labeled a 5-day (school day) dietary diversity register (DDR). The teachers sought each preschooler's open recall of what they ate at home over the previous 24 hours, on every school day. They recorded the responses on the DDR by checking the boxes on the corresponding food or food group row and within the given date column (see *Appendix C*).

Consequently, using the DDR tool, the study captured independent counts of OFSP consumption days among the preschoolers during the intervention period. It captured their 24-hour recall consumption data five times a week - covering food consumed from Sunday through Thursday - for four consecutive weeks in September and October 2018. One of the days (October 10) was a holiday; thus, the consumption data were collected for 19 days. A total of 385 complete observations were collected using the DDR and reduced to 373 observations after excluding 17 cases of rampant absenteeism (≥10 days) among the preschoolers.

The teachers were trained and tested on a reliable collection of the preschoolers' food consumption data using the DDR. In addition, both groups of enumerators - survey enumerators and class teachers - were blinded to the allocation of interventions and the motive of the adjustment in the dietary diversity register.

5.3.2 Measurement of OFSP Consumption Frequency

According to the World Health Organization (2015), the frequency of consumption is the number of days of consuming a food or food group over a reference period of time. The outcome variable, OFSP consumption frequency, was computed as the sum of days when the preschooler consumed an OFSP food as recorded in the DDR. This gave a count variable with values expected to range between 0 and 19.

5.3.3 Data Analysis

The data on the outcome variable, OFSP consumption frequency, were collected for one harvesting period in 2018. Thus they were analyzed as cross-sectional data. The analysis involved 373 observations with covariates drawn from the baseline household-level survey and the outcome variable from the DDR data. First, the exploratory analysis involved the tests for differences in the preschooler, caregiver, and households' socio-demographic variables between the control and treatment groups for comparability. Significant mean differences in OFSP consumption frequency and other variables between the control and each of the treatment groups were also checked using unpaired t-test and Mann-Whitney U test.

5.3.3.1 Zero-inflated Poisson

The dependent variable (frequency of OFSP consumption) was measured as a count variable with values 0, 1, 2, …. *K*. Therefore count models were considered to regress the OFSP consumption frequency on the intervention variables and other covariates. The standard Poisson regression model (PRM) is the most common model for count data conditions. It assumes equidispersion of the dependent variable (the variance of the data to be equal to its mean), and

that it must hold for the model to produce correct standard errors and a valid significance level (McCullagh, 2019). Other models have been considered in the case of over-dispersion of the dependent variable, a common violation of the equidispersion assumption in the Poisson model. It follows that a negative binomial regression (NBRM) would fit in case of overdispersion. In case the overdispersion is due to excessive zeros, then other alternatives; zero-inflated Poisson (ZIP) and Zero-inflated negative binomial model (ZINB), are considered. The former is the best fit when the over-dispersion is due to excessive zeros only, whereas the latter fits when there are excessive zeros as well as over-dispersion from the non-zero integer values of the data (Long and Freese, 2006; Jiang and House, 2017).

In this study, many scenarios leading to non-consumption of OFSP meals were expected. For instance, either the caregivers did not plant the vines thus had no access to the roots; they failed to harvest for various reasons, including poor yield; caregivers misallocated time, or they dislike the food variety. On the other hand, some caregivers may also feed their children on OFSP for several days due to their general liking, when it is the only food at the household's disposal for consumption, or as an effect of the nutrition education interventions. Given such possibilities, the data would not meet the equidispersion assumption; thus, the PRM would not fit.

From the design of the experiment, cases of zero frequency of OFSP consumption could arise if the household did not grow the OFSP (structure zero) or if the zero consumption is the corner solution of a standard consumer demand problem (sampling zero). Based on these assumptions, a zero-inflated count model was chosen over the standard PRM, NBRM, and the Hurdle models, which assume that all zeros in the count data are due to sampling zeros as proposed by Mullahy

(1986). However, the PRM, NBRM, and zero-inflated negative binomial regression model (ZINBRM) were also estimated for comparison of the model fitness.

Zero-inflated Poisson (ZIP) regression model is recommended as one of the alternative ways of addressing over-dispersion when excessive zeros are expected in the observations. In this instance, the distribution of the ZIP regression is a modification of the logit and Poisson distributions (Jiang and House, 2017).

The ZIP model can be specified as follows:

$$Pr(Y_i = y_i|x_i) = \begin{cases} p + (1-p)\exp(-\lambda_i) & if\ y = 0 \\ (1-p)\frac{\lambda_i{}^{y_i}e^{-\lambda_i}}{y_i!} & if\ y > 0 \end{cases} \quad \ldots\ldots (5)$$

wherey_i is the frequency of OFSP consumption of a preschooler from household i, p is the probability of zero frequency OFSP consumption in the reference period, and $\exp(-\lambda)$ is the density function of the data generating process that produces the food frequency score during the intervention period conditioning on the caregiver's decision to prepare the OFSP meals. In the model, $E = (Y) = \mu = (1-p)\lambda$ and $Var(Y) = \mu + \frac{p}{1-p}\mu^2$. ZIP model is a special form of the Generalized Linear Models and has a link function.

The two functions are specified as;

$$Logit\ (p) = Log\left(\frac{p}{1-p}\right) = x'\beta \quad \ldots\ldots (6)$$

$$Log(\lambda) = z'\alpha \quad \ldots\ldots (7)$$

where x and β are the covariates and parameter estimates of the first stage, respectively. Similarly, z and α are the covariates and parameter estimates of the second-stage regression, respectively.

The implicit functional form of the ZIP model used to estimate the number of days the preschoolers were fed on OFSP was specified as;

$$CONSUMPTION_{ihv} = \beta_{intervention} INTERVENTION_{ihv} + \beta_{child} CHILD_{ihv} + \beta_{caregiver} CAREGIVER_{ihvs} + \beta_{hh} HH_{ihv} + \beta_{village} VILLAGE_{ihv} + V_v + \varepsilon_{ihv}$$

…..…… ……(8)

The primary dependent variable (CONSUMPTION) is the frequency of OFSP consumption of preschooler *i*, in household *h*, that is located in village *v*. In addition to the main focus variables (INTERVENTION) of the nutrition education approaches, the study controlled for vectors of preschoolers (CHILD), caregiver (CAREGIVER), household (HH), and village (VILLAGE) level characteristics. Further, the village cluster (V) fixed effects were also controlled for. The notations β and ε denotes the coefficient estimates and the disturbance term, respectively.

While estimating the ZIP model, potential zero consumption frequencies (zero inflation) were predicted by whether the caregiver cultivated the crop (dummy) and average monthly household expenditure. The model would not converge when more variables were added to predict zero inflation. In addition, to arrest a potential estimation problem due to the small sample size - 15 clusters and many predictors - the ZIP model estimation space was adjusted by bootstrapping the sample at 1000 replications as recommended by Long and Freese (2006).

5.3.3.2 Goodness-of-fit: Four Information Criteria

Following Long and Freese's (2006, 2014) recommendations, the best fitting count model was assessed by comparing the PRM, NBRM, ZIP, and ZINB models based on three goodness-of-fit statistics; Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and the Likelihood Ratio Test. The Vuong test is omitted for its inappropriate for comparing models with zero-inflation (Wilson, 2015). Overall, the ZIP model had the largest log-likelihood, and smallest AIC and BIC, which implies the best relative goodness-of-fit.

5.4 Results

5.4.1 Summary Statistics

The analysis involved 373 observations from both preschoolers and caregivers, as 17 cases were lost to rampant absenteeism from school among the preschoolers. These were distributed as 98, 70, 79 and 126 in the control, PT, IT and CT groups, respectively.

Table 9 presents the descriptive statistics (overall mean and standard deviation and mean difference between control and treatment groups) of the socio-economic characteristics of the households, including the caregivers and the preschoolers. It also presents the balancing tests of the covariates (at baseline) in assessing the effectiveness of the randomization in delivering comparable groups. The first column (1) shows the mean and standard deviation of the variables in the overall sample. The other columns (2 -5) present the mean differences in the variables between the control and the treatment groups. These are results of Mann-Whitney U tests and the student's t-tests of difference in the variables between two samples - control and every treatment group - with unequal variance. The groups balanced well in most of the socio-economic variables except for the caregivers' age, monthly household expenditures, which were higher in

control than each of the treatment groups. These variables were included as regressors in the model to control for possible randomization bias.

Overall, the preschoolers were averagely six years (range 4-7) old, with the girls dominating at 58 percent. As expected, a majority of the caregivers were women (92 percent) with an average age of (36 ±12 years). Also, 4 in 5 households had children under-5 years old. Therefore, the sample makes a perfect case for VAD vulnerable groups (women between 15 -49 years old and under-5-year-old children). The average size of the households ranged between 6 and 7, with a monthly household expenditure of Kshs 7000. Also, a minority (17.2 percent) of the caregivers had attempted post-primary school education levels. This attests to the low education standards among the residents of the rural farming households. Perhaps, due to the training during the cooking demonstration workshops and dissemination of the free-vines, the caregivers had good knowledge of OFSP consumption (93.5 percent), good knowledge of Vitamin A sources and nutritional benefits (65.2 percent), and good attitude towards the food (62.6 percent).

Table 9: Summary Statistics and Test for Differences in Variable Means between Control and Treatment Groups (at Baseline) for Sample Used in Consumption Analysis

	(1) Full sample	(2) Control – PT	(3) Control – IT	(4) Control - CT	(5) Control - All treatments
Variables at Baseline	**Mean(SD)**	**Diff(SE)**	**Diff(SE)**	**Diff(SE)**	**Diff(SE)**
Child's Age (Years)	5.646	0.161	0.117	0.220	0.176
	(1.089)	(0.171)	(0.168)	(0.147)	(0.130)
Child's Gender (Female)	0.579	0.081	0.012	-0.0454	0.003
	(0.494)	(0.078)	(0.075)	(0.066)	(0.058)
Caregiver's Age (Years)	35.941	3.914**	7.038***	2.468	4.149***
	(11.514)	(1.785)	(1.652)	(1.671)	(1.454)
Caregiver's Gender (Female)	0.920	-0.069*	-0.049	-0.025	-0.043
	(0.272)	(0.040)	(0.042)	(0.041)	(0.036)
Caregiver has a post-primary education (dummy)	0.172	0.022	0.017	0.043	0.031
	(0.378)	(0.061)	(0.059)	(0.051)	(0.046)
Caregiver is Married (dummy)	0.831	-0.022	-0.067	-0.019	-0.034
	(0.375)	(0.061)	(0.055)	(0.053)	(0.046)
Caregiver's Occupation	0.265	0.035	0.032	-0.130**	-0.042
	(0.442)	(0.065)	(0.063)	(0.061)	(0.051)
Member of a farmers group (dummy)	0.327	0.053	0.0129	0.082	0.055
	(0.470)	(0.074)	(0.073)	(0.064)	(0.056)
Caregiver is the HH head (dummy)	0.413	0.102	0.067	0.039	0.063
	(0.493)	(0.077)	(0.075)	(0.067)	(0.059)
HH Size (counts)	6.228	0.041	0.284	0.303	0.231
	(2.164)	(0.352)	(0.327)	(0.312)	(0.277)
HH has under-5 year old (dummy)	0.799	0.008	-0.020	-0.092*	-0.046
	(0.401)	(0.067)	(0.063)	(0.053)	(0.049)
HH Monthly Expenditure ('000 Kshs.)	7.004	2.417*	4.261***	2.974**	3.202***
	(7.296)	(1.236)	(1.087)	(1.183)	(1.074)
Child Dietary Diversity Score	4.316	-0.224	0.153	0.331*	0.138
	(1.221)	(0.181)	(0.173)	(0.176)	(0.149)
Child had a Diverse Diet	0.764	-0.135**	-0.007	0.083	0.002
	(0.425)	(0.056)	(0.064)	(0.060)	(0.050)
Household Food Security Score	11.643	-0.490	-0.237	0.026	-0.181
	(5.993)	(0.902)	(0.906)	(0.803)	(0.686)
Grew OFSP to maturity in 1st season (0/1)	0.598	0.245***	0.356***	0.446***	0.370***
	(0.491)	(0.071)	(0.068)	(0.058)	(0.047)
Produced OFSP 1st season (dummy)	0.595	0.243***	0.351***	0.421***	0.355***
	(0.492)	(0.069)	(0.067)	(0.057)	(0.046)

Variables at Baseline	(1) Full sample Mean(SD)	(2) Control – PT Diff(SE)	(3) Control – IT Diff(SE)	(4) Control - CT Diff(SE)	(5) Control - All treatments Diff(SE)
OFSP plot size (squared metres)	23.810 (45.555)	9.482 (8.202)	17.84** (7.492)	20.93*** (6.479)	17.13*** (6.303)
Distance to nearest HF (walking minutes)	34.332 (24.000)	7.794** (3.679)	3.061 (3.855)	6.662* (3.829)	5.916* (3.433)
Distance to nearest CHV (walking minutes)	15.062 (15.387)	7.686*** (2.092)	2.181 (2.275)	-2.437 (2.408)	1.466 (2.065)
OFSP consumption knowledge (baseline) (0-1)	0.936 (0.143)	0.007 (0.024)	0.009 (0.020)	0.003 (0.019)	0.006 (0.016)
Knowledge of Vitamin A (Baseline) (0-1)	0.654 (0.306)	0.067 (0.051)	0.027 (0.044)	0.041 (0.040)	0.043 (0.035)
Attitude towards OFSP (baseline) (0-1)	0.626 (0.103)	0.000 (0.017)	-0.005 (0.015)	-0.017 (0.015)	-0.009 (0.013)
Outcome Variables					
Preschooler Consumed OFSP (dummy)	0.662 (0.474)	0.145** (0.069)	0.145** (0.066)	0.285*** (0.060)	0.209*** (0.049)
OFSP consumption frequency(counts)	1.440 (1.512)	0.141 (0.223)	-0.185 (0.247)	0.549*** (0.171)	0.234 (0.156)
Consume at least ONCE per week(1 in 5 days)	0.094 (0.292)	-0.0163 (0.034)	-0.174*** (0.051)	-0.039 (0.031)	-0.072** (0.028)
Observations	373	168	177	224	373

Note: Column 1 displays the mean of the overall sample with standard deviation in parentheses. Columns 2 to 5 display mean differences between control and treatment groups with standard errors in parentheses. PT = Group assigned books, posters and poems to preschoolers. CT = Group assigned mobile phone mediated text messages to caregivers alone. IT = Group assigned both books, posters and poems to preschoolers as well as phone text messages on OFSP and nutritional benefits to the caregivers simultaneously. HH= Household. HF= Health facility. CHV=Community Health volunteer.

* p<0.10, ** p<0.05, *** p<0.01

Source: Survey Data (2018).

5.4.2 The Relationship between OFSP Production and Consumption Trends

A relatively higher proportion of preschoolers consumed OFSP in the control than the treatment groups. Perhaps this replicates the fact that the control group also had a significantly higher percentage of those who cultivated the crop than the rest of the groups. As expected, there was a significant relationship between the caregivers' production of OFSP and the preschoolers' consumption across all the study groups (*p*-value = 0.000; Fisher's exact tests). Overall, preschoolers who consumed OFSP were from 95 percent of households where OFSP was produced and 24 percent of households that failed to cultivate the crop. The latter statistic draws more attention into the food access pattern and what influenced their consumption. Figure 7 below provides more insights into the interaction between OFSP cultivation and consumption across the study groups.

Also, the mean frequency of consumption of OFSP varied significantly across the study groups (Kwallis test; Chi-square = 17.078; *p*-value = 0.0007). The mean consumption frequency was significantly higher in the IT group than in the CT group ($p = 0.0101$), and in the control group than in the CT group ($p = 0.0004$). On the other hand, despite all groups recording a mean frequency greater than 1, the assignment of the IT group treatment was the only approach significantly associated with OFSP consumption for at least once in a 5-day week, on average terms.

The results show that while the production of the OFSP was strongly associated with its consumption among preschoolers (Pearson's Chi-square = 198.23; *p*-value = 0.000), about 5 percent of caregivers who produced OFSP did not feed it to their preschoolers. This shows that while production is very important for the availability of nutritious crops, it does not confirm

outright feeding of the preschoolers on the same (see Figure 7). This significantly varied between the control and IT group (Pearson's Chi-square = 4.911; p-value = 0.027), and between the IT group and the CT group (Pearson's Chi-square = 4.022; p-value = 0.045). Also, a significant proportion of those who did not produce OFSP fed their preschoolers on the same (24 percent, n =151). Potentially, these results point to the power of the intervention approach in enhancing the consumption of OFSP roots among the social networks of the direct targets.

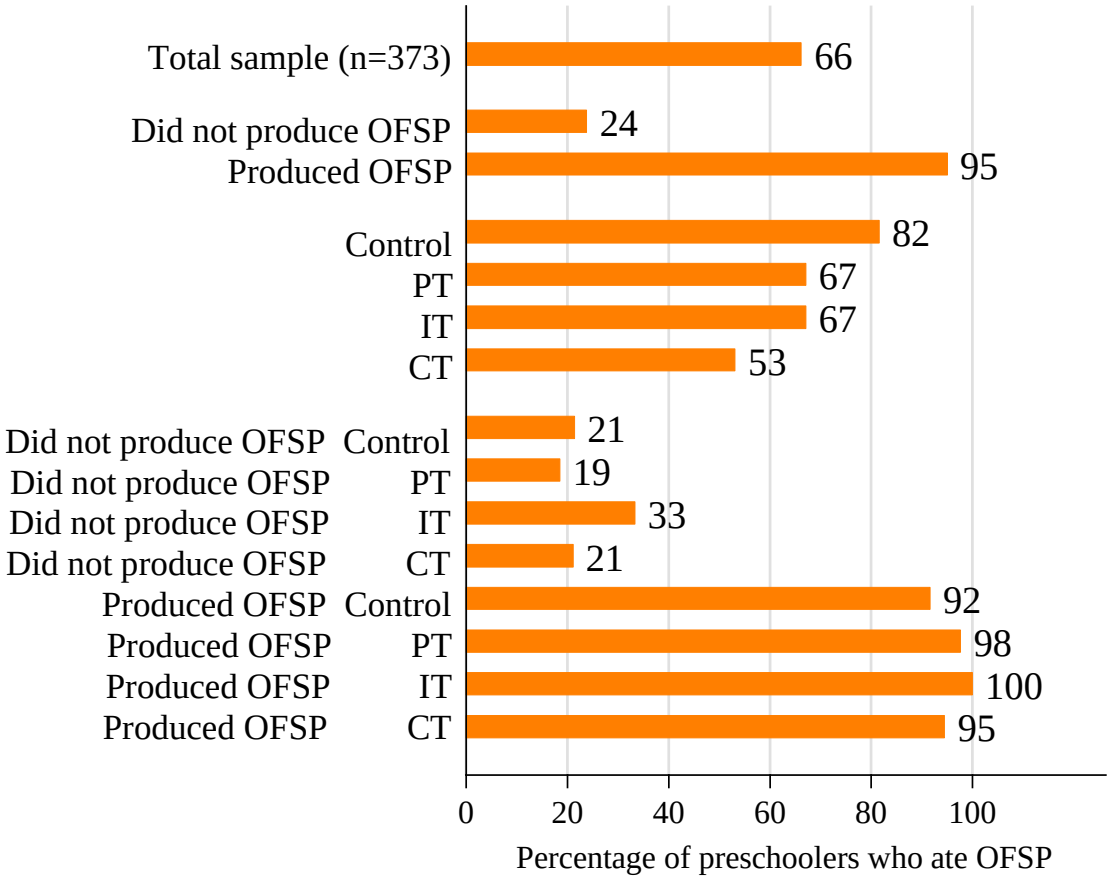

Figure 7: Distribution of Consumers of OFSP across the Study Groups and OFSP Production

Source: Survey data (2018)

Figure 8 below shows the distribution of the preschoolers' consumption frequencies by the study groups and the category of those who produced and those who failed to produce the crop. Apparently, there were large proportions of non-consumers of OFSP in the category of non-producers, and relatively greater percentages in the higher consumption frequencies in the producers' category.

It is important to note, the IT group recoded higher percentages in higher consumption frequencies than the other study groups in both categories.

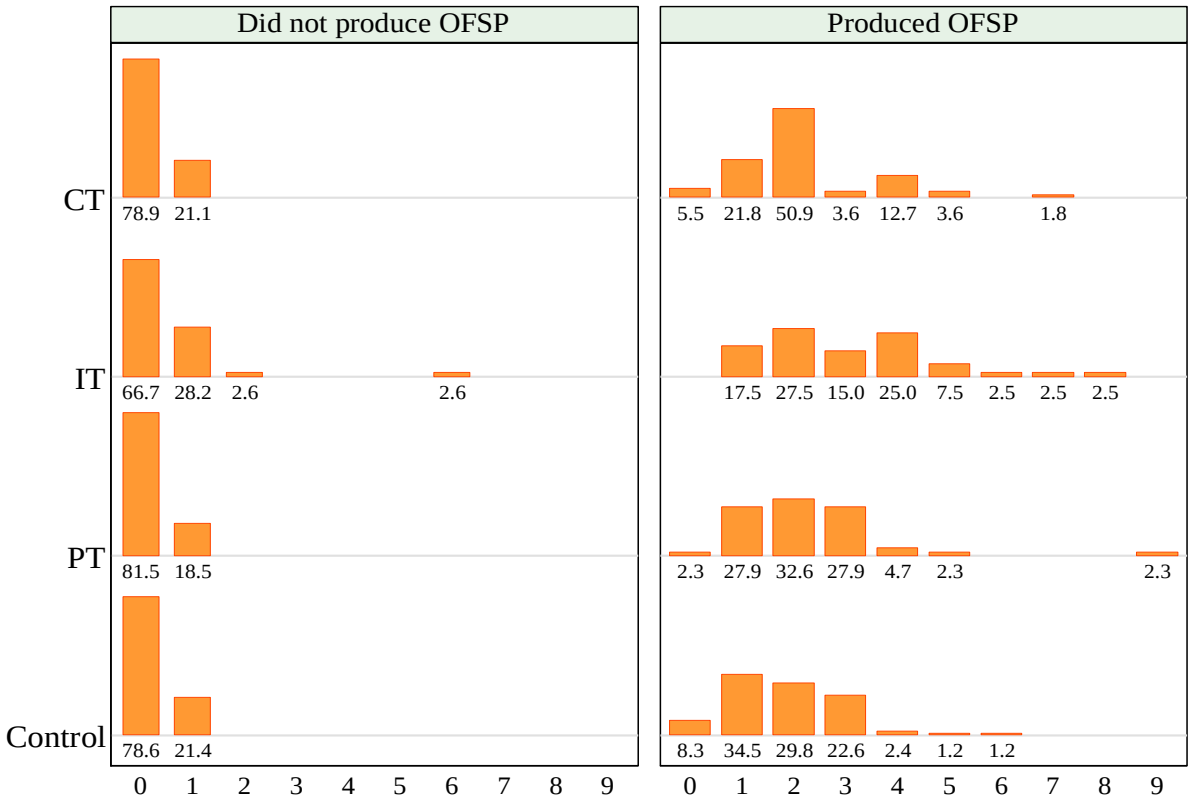

Figure 8: Percentage of Preschoolers by OFSP Production and Frequency of Consumption in the Study Groups

5.4.3 Effects of Nutrition Education Intervention on OFSP Consumption and Consumption Frequency

Table 10 below presents the estimates (coefficients and average marginal effects) of the interventions on consumption, frequency of consumption, and average OFSP weekly consumption days after controlling for child, caregiver, household factors, and village fixed effects. A broader model with many controls is presented in *Appendix D* for comparison. The model specifications in Table 10 have better goodness of fits - due to the smaller Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) statistics and higher log-likelihood ratio scores - than the specifications in *Appendix C*.

Holding other factors constant, a preschooler whose caregiver is assigned to receive the nutrition education from multiple channels (IT) will increase their probability to consume OFSP by 11.5 percent, and their probability to consume OFSP at least one times in every five days by 20.4 percent relative to a case where no nutrition education is assigned. Again being in the IT group and CT group significantly enhances an individual's OFSP consumption frequency by 76.6 percent and 21.2 percent, respectively, relative to a case with no complementary nutrition education at all.

The IT had greater effects relative to the CT, while PT induced no significant effects. Besides, the IT had stable coefficient and marginal effect estimates between the two specifications in Table 10 and Appendix C. In addition, the negative and positive signs in parameters estimated for zero inflation (OFSP cultivation and the household expenditure) variables in estimation of the likelihood of non-consumption of OFSP commensurate the expectations as guided by previous literature. Thiele et al. (2009), for instance, observed that sweetpotato consumption is negatively

Table 10: The Effect of Nutrition Education Interventions on the OFSP Consumption and Consumption Frequency

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables =	Consume		Consumption Frequency		Consume ≥1 per week	
	Binary Logit		**ZIP**		**Binary Logit**	
	Coefficient	dy/dx	Coefficient	dy/dx	Coefficient	dy/dx
Main						
PT Group	0.547	0.0482	0.205	0.269	0.713	0.0262
	(0.333)	(0.289)	(0.219)	(0.249)	(0.280)	(0.311)
IT Group	1.228*	0.115**	0.499***	0.766**	2.663***	0.204**
	(0.064)	(0.047)	(0.006)	(0.024)	(0.002)	(0.042)
CT Group	0.504	0.0443	0.164**	0.212**	1.593***	0.085***
	(0.449)	(0.405)	(0.031)	(0.024)	(0.003)	(0.002)
Child's Age	-0.0301	-0.0030	0.0078	0.0112	0.302*	0.0198*
	(0.906)	(0.906)	(0.854)	(0.853)	(0.098)	(0.082)
Education	0.384	0.0378	0.0663	0.0954	-0.526	-0.0345
Category	(0.293)	(0.306)	(0.172)	(0.183)	(0.275)	(0.282)
Marital status	-0.102	-0.0100	0.228*	0.328*	1.189	0.0779
	(0.869)	(0.869)	(0.062)	(0.063)	(0.100)	(0.121)
Farmer group	0.345	0.0340	0.162**	0.233**	0.794	0.0520
(dummy)	(0.161)	(0.144)	(0.033)	(0.049)	(0.116)	(0.123)
Distance to	-0.0297	-0.0029	-0.0004	-0.0006	-0.0898	-0.0059
CHV	(0.781)	(0.781)	(0.987)	(0.987)	(0.426)	(0.428)
Produced OFSP	4.408***	0.434***	1.730***	3.051***	3.668***	0.240***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(log) Monthly Expenditure				-0.057*** (0.005)		
Constant	-1.651		-4.340***		-9.511***	
	(0.452)		(0.000)		(0.000)	
Inflate						
Produced OFSP			-24.61***			
			(0.000)			
Monthly			2.485			
Expenditure(log)			(0.110)			
Constant			-22.23			
			(0.105)			
Chi-square	496.1		679.4		115.0	
p-value	0.000		0.000		0.000	
Log-likelihood	-122.9		-464.4		-82.29	
AIC	265.9	.	954.9	.	184.6	.
BIC	305.1	.	1005.8	.	223.8	.

Note: The total sample consists of observations from 373 preschoolers who reported to the institution for at least 11 of the 19 days and gave their food consumption recalls. *P*-values in parentheses are robust to clustering at village levels. Estimation of the ZIP model was exposed to the variable '*present'* (the total number of days that the child turned up to the ECD center).

* p<0.10, ** p<0.05, *** p<0.01.

Source: Survey Data (2018).

related to household income due to its presumption as a poor man's crop in SSA, technically a label of an inferior good. However, consumption was less expected among non-producers as OFSP was not sold around.

5.5 Discussion

Promotion of the biofortified crops in the rural society have majored on availing planting materials, training on production and consumption behavior, and nutrition education at production stages. These approaches have been based on the premise of a direct nexus between food production, availability, and consumption at the household levels. The findings of this study replicate the conventional wisdom; however, with caution that not all OFSP producing households feed it to their preschool children (Figure 6). This challenges the sustainability of the existing OFSP promotion approaches; the gap between production and consumption of OFSP may vary with many factors, including poor post-harvest management, seasonality, and cost of accessing the roots (Bekele and Turyashemererwa, 2019) and time-lapse since initial introduction. For instance, Okello et al. (2019) found a similar limitation with cooking demonstrations and field days on the likelihood of the project beneficiaries to share the vines a year after a lapse of the projects.

Perhaps, such gaps could be bridged by complementary agri-nutrition education interventions that target the VAD vulnerable groups through different channels, simultaneously, as demonstrated in this study (Figure 7). The IT approach ensured every household that produced OFSP fed it to the preschoolers. Further, it also registered higher potential influence on the non-producing households to seek OFSP and feed their children.

The OFSP success story on improving nutrition status is heavily grounded on the efficacy trials, such as van Jaarsveld et al. (2005) that linked OFSP consumption to changes in the vitamin A levels in the target's body. A common takeaway from these experiments is the intensive (subjective daily) consumption of OFSP (Greiner, 2017; Hotz et al., 2012; Haile and Getahun, 2018). Previous studies have researched on improving the probability of OFSP consumption, with little to no study on how to enhance the intensity or frequency of OFSP consumption over time. Sakala et al. (2017) findings on the association between knowledge and consumption of OFSP argue for the need to provide behavior change communication campaigns. However, it is not certain that any method of behavior change communication would improve consumption.

Whereas it is almost certain that they would meet the daily dietary requirement for vitamin A on any day that the children consumed OFSP, consumption of the nutritious food in more frequent days is necessary for a regular and stable supply of dietary needs. It is, thus, imperative to focus on increasing the rate of consumption of OFSP over time. While the preschooler-oriented nutrition education approach alone induced no significant effects on OFSP consumption, its role in reinforcing the messages delivered through the mobile-phones is acknowledgeable in the results of the IT approach. The IT approach significantly improved the consumption of OFSP at all levels. It improved the likelihood of consuming OFSP, the likelihood of increasing the

frequency of its consumption, and the probability of consuming it more than once in 5 days. Therefore, it confirms that a multi-channel complementary nutrition-education involving preschoolers and caregivers may enhance the likelihood and frequency of OFSP consumption among rural-farming households.

5.6 Conclusion

Based on the findings, this study concludes that there is still a low prevalence of the practice of feeding OFSP to preschool children even in the harvesting periods. Production of OFSP is necessary to ensure availability of the nutritious food in the households, but that alone does not assure presence of the food in the menus of the neediest group. The study demonstrates that complementary nutrition education involving preschoolers and their caregivers is a significant approach in filling the gap - ensuring the utter consumption of the produce among the preschoolers. Both single and multichannel approaches can be effective in improving the frequency of OFSP consumption, although a preschooler-oriented approach seems not to influence any potential to consume OFSP when not supported with other approaches. However, the phone-mediated text messaging can deliver significant changes in consumption frequency even when issued as solitary complementary nutrition education. Contemporary and future agriculture-nutrition education programs should consider both the mobile messaging technology and the preschoolers as effective platforms for promoting sustainable consumption of nutritious food crops.

CHAPTER SIX: GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1 General Discussion

The foundation of this study was based on the fact that despite the concerted efforts on the path to ending hunger and malnutrition, the progress is, however, slower, especially when compared to the rising population growth rate at above 2 percent per annum. Bio-fortification of staples has been widely acknowledged as a cost-effective and sustainable way of alleviating malnutrition problems, especially in SSA, where the most micronutrient deficiency vulnerable groups are the low-income, rural farming households. Identification of more sustainable and adaptable agriculture-nutrition sensitive interventions has been the lead focus of recent research and development work. This study contributes to literature by providing new evidence on how the OFSP technology could be effected with a focus on reaching the target households through the ECD platforms with integrated agriculture-nutrition education interventions.

The study involved experimenting with preschooler-caregiver pairs who were randomly assigned into either a treatment or a control group at the village-level clusters. The three treatments involved the issuance of nutrition education interventions to the preschoolers only, to the caregivers only, or to both preschoolers and caregivers, simultaneously, for 30 days. Baseline and follow up data were collected before and after the intervention from the caregivers. The preschoolers provided their food consumption data during the intervention period. The study used the data to test the three hypotheses that integrated nutrition education approaches; i) do not improve the knowledge, attitude and practices (KAP) of the caregivers around OFSP; ii) do not improve the likelihood of the caregivers to replant OFSP after phase-out of the free vines

dissemination projects; iii) do not enhance the consumption of OFSP among preschool children. Generalized linear models with bootstrapping, a binary logit regression and special regressor model; and a zero-inflated Poisson model were used to test the hypotheses, respectively.

At exploratory levels, the study found that ECD centers are practically good avenues for reaching end-users of agri-nutrition technologies such as OFSP. The vast majority of the households were VAD high-risk groups, and the interventions ensured intensive contact with the targets with relatively more personalized interventions.

Further, the study found sufficient empirical evidence that single-channel nutrition education interventions were effective in improving 2 of the 3 knowledge constructs regarding OFSP, multi-channel approach improved all components of OFSP knowledge construct and reported higher marginal effect estimates on all. However, only the phone-mediated messaging approach induced significant positive effects on the caregivers' attitude towards OFSP.

Regarding the production of OFSP, the study finds that only a multi-channel nutrition education approach significantly improved the likelihood of the caregivers to retain the vines in their farms after elapse of the free-vines dissemination project. That is, issuing of OFSP-branded exercise books, posters and poems to preschool children and phone-mediated text messages to caregivers about all matters OFSP and its nutritional benefits improves the potential of the caregiver to replant the OFSP vines in subsequent planting seasons. In essence, the multi-channel approach provides a combined nudging effect on the caregiver that pushes their decision to conserve the vines and replant in the subsequent seasons when the free-vines dissemination project has lapsed.

There is still a low prevalence of the practice of feeding OFSP to the preschool children even in the harvesting periods. While the production of OFSP assures availability of the nutritious food in the household, complementary nutrition education is needed to ensure the utter consumption of the produce among the preschoolers. Both single and multi-channel approaches can be effective in improving the frequency of OFSP consumption, although a preschooler-oriented approach seems not to influence any potential to consume OFSP. However, the phone-mediated text messaging can deliver significant changes in consumption frequency even when issued as solitary complementary nutrition education.

Overall, while the effectiveness of the single-channel approaches varied across different outcomes, the multi-channel approach induced highly significant effects in a majority of the outcome scenarios. Relatively, it also registered a higher magnitude of effects compared to the single-channel nutrition education approaches. This observation argues for the need to integrate multi-channel nutrition education interventions to boost the potential of the agri-nutrition sensitive technology to achieve respective objectives around nutrition security in the society.

In extension, it is imperative to point out that ensuring sustainable adoption and consumption of nutritious foods will inspire significant improvement in their local demand and supply and enhance their terms of trade at different levels of the associated value chains. Also, in the long-run it would be possible to assess the effect of the nutrition education interventions and sustainable adoption of the OFSP in alleviating the cost of malnutrition in the economy in terms of health, education, productivity and potential economic investments. This is with reference to the related literature that management of child undernutrition and its effects cost the Kenyan economy 6.9 percent of its GDP (Republic of Kenya, 2019).

6.2 Conclusion

The study concludes that significant VAD target group can be reached effectively with novel complementary nutrition education interventions via the ECD platform. A multi-channel-oriented nutrition education involving preschoolers and phone-mediated text messages to the caregivers is an effective strategy of influencing caregivers' knowledge empowerment and behavior change regarding retention of OFSP and feeding the OFSP roots to the preschoolers. In essence, interventions targeting preschoolers only are more effective in improving knowledge of caregivers, while those that specifically target caregivers through mobile-phone mediated messaging are effective in influencing caregivers' knowledge of and attitude towards OFSP.

The study has established the linkage between routine agriculture interventions and the intermediaries' goals on the pathway to nutrition security as complementary nutrition education interventions involving the caregivers and the preschoolers. It has also established that combining different complementary nutrition education delivery channels enhances the effectiveness of the behavior change communication initiative among the target group. Specifically, retention of OFSP vines at farm levels, knowledge development, and frequency of OFSP consumption can be enhanced with a multi-channel nutrition education offered after the introduction of the technology to the households.

6.3 Recommendations

The study points to the need to enhance consideration of the recommendation for the government to step up strong educational support to the production, distribution, and consumption of nutritious crops to combat the undernutrition problem. The findings also imply that targeted and

integrated nutrition education channeled through ECD can be effective in ensuring improved access to nutritious crops such as the OFSP.

Given the huge importance of OFSP and the ECD platform, access to and participation in interventions channeled through this platform has a critical potential to accelerate the fight against VAD in the society. As such, the emerging improvements in the designs of interventions that integrate biofortified foods, nutrition education, and ECD platform as target outreach and intervention channeling platforms hint at the prospect of a more scalable and sustainable approach to combating malnutrition, especially in the rural SSA region.

Policy developers such as the government ministries of education and health, in charge of the Early Childhood Development and Education programs, can reach to the malnutrition target groups with information on the preschoolers learning materials, simply by directing the standard labeling of the preschoolers learning materials with pretested information packages harmonized context-specific nutrition education information.

Similarly, the penetration of mobile phones in Kenya's rural society when checked with the demonstrated success of the mobile phone-mediated messaging approach presents a huge potential for reaching a large share of the target population with the nutrition education. However, tailoring the messages is needed to optimize the potential of realizing the desired outcomes. In addition, it is imperative to recall that the potential of the targeted complementary nutrition education is enhanced by their integration. Interventions that links to a common target or outcome but have fitted different delivery channels can be integrated to improve the potential of a combined approach.

In order to encourage adoption and scale-up of the studied nutrition education interventions, further research is needed to explore their cost-effectiveness relative to other complementary interventions such as training of expectant and breastfeeding mothers during pre-and-post natal care. It is also important to measure, and factor in the scalability of either nutrition education intervention approaches to be compared.

The study reports variations in the effectiveness of the single-channel nutrition interventions, but makes no effort to understand the success and failure pathways. Accordingly, future studies may incorporate internal intervention appraisal components such as decoding of the received information. This will help with the understanding the potential of information loss and mismanagement when executed through different channels.

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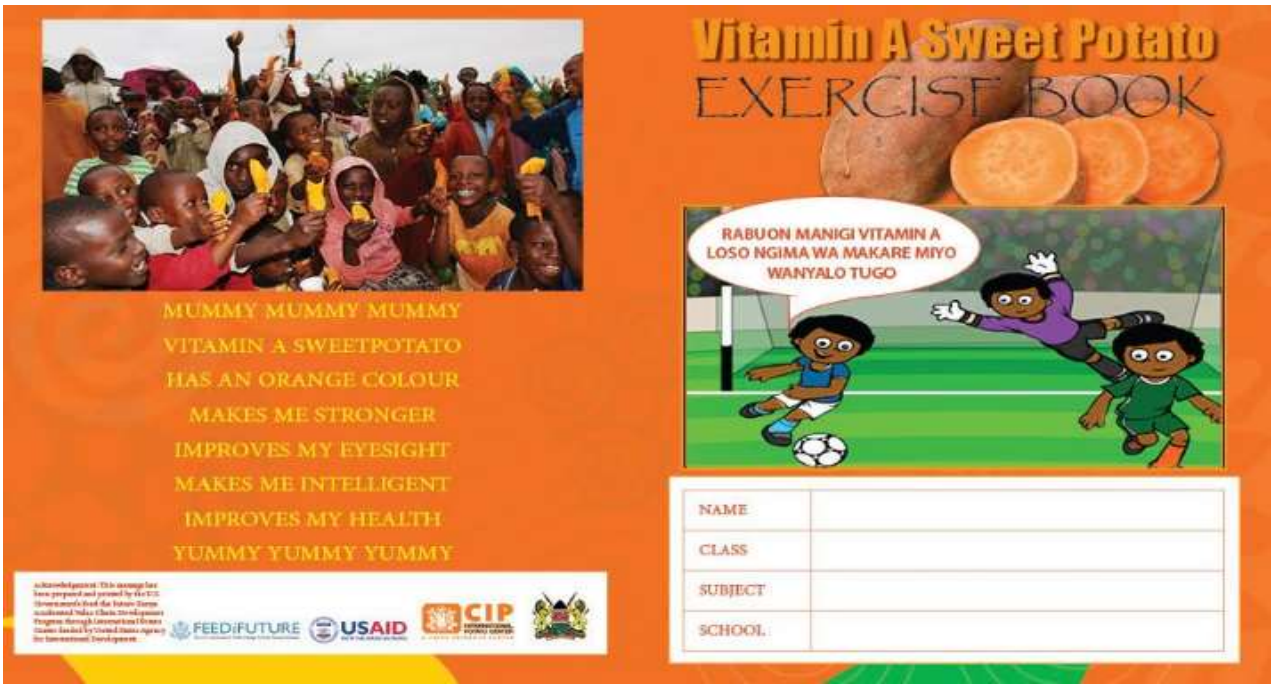
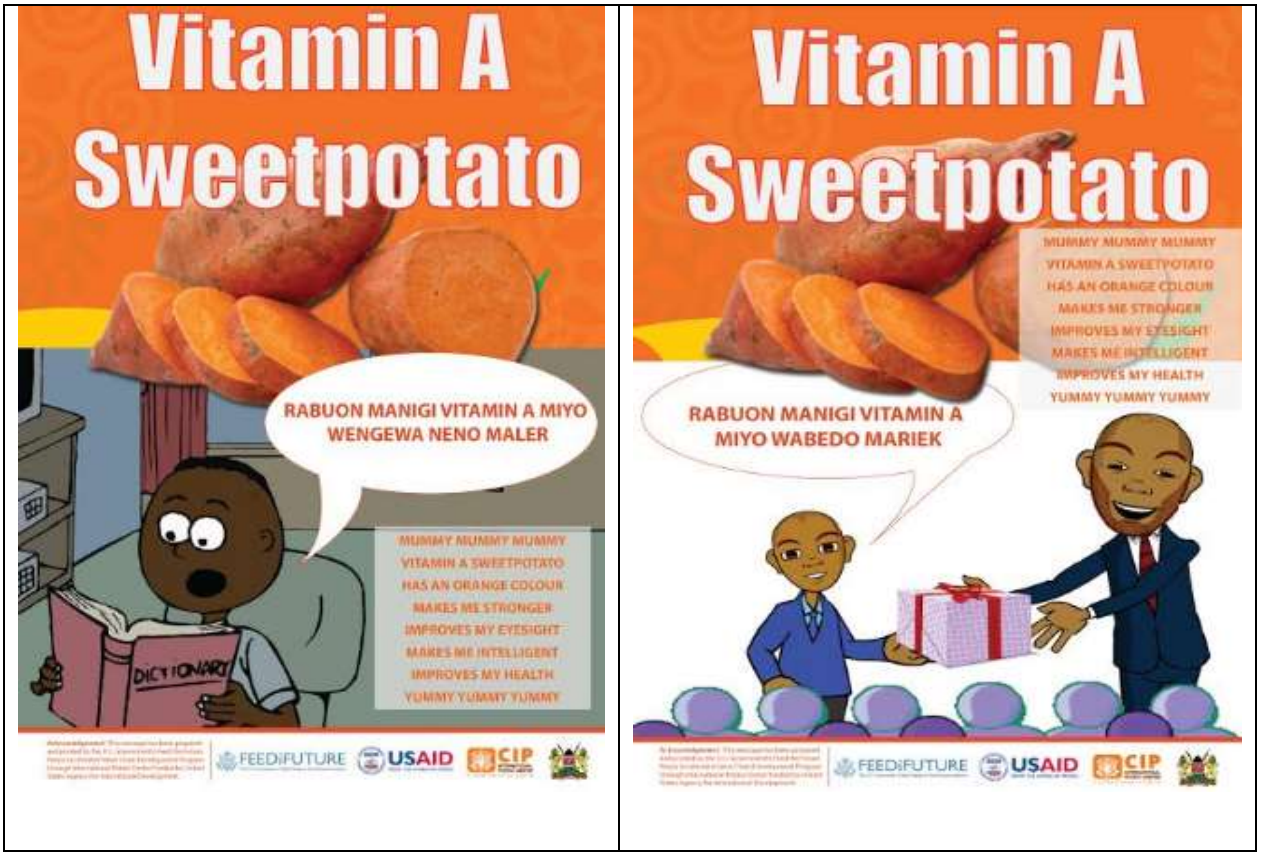
APPENDICES

Appendix A: Sample Treatment Materials

Appendix A1: A Sample Cover Page of OFSP-Branded Exercise Books



Appendix A2: Sample OFSP-Branded Class Posters



Appendix A3: Mobile Phone-Mediated Messages

English	**Dholuo (*The local dialect*)**
1. Vitamin A sweetpotato is orange in colour	*RABUON MANIGI VITAMIN A RANGINE RATONG' MA OHOORE.*
2. Vitamin A helps our bodies to prevent diseases.	*VITAMIN A KONYO DENDWA GENG'O TWOCHE.*
3. Vitamin A sweetpotato is good for children aged 6 months and above.	*RABUON MARATONG' MA OHOORE BER KUOM NYITHINDO MANIGI DWECHE 6 KADHI MBELE*
4. Boiling! Use little water, low heat for a short time.	*CHWAKE GI PI MATIN, MACH MAMUOL, E SAA MACHUOK.*
5. It is best steamed, mashed or mixed in your family foods.	*OBER KABISA KA OCHWAKE GI MUYA MALIET, KONYWASE, KATA KA ORIWE GI CHIEMO MA MOKO MAJO OT CHAMO.*
6. Vitamin A sweetpotato is available in your local market.	*RABUON MARATONG' MA OHOORE YUDORE E CHIRO MAN MACHIEGNI KODI.*
7. Remember! Vitamin A sweetpotato is planted just like the other sweetpotato.	*BED KAING'EYO NI RABUON MARATONG' MA OHOORE IPIDHO MANA KAKA RABUON MA MOKO.*

Appendix B: Household Survey Questionnaire

ANALYSIS OF THE PERCEPTIONS AND EFFECTS OF NUTRITION MESSAGING APPROACHES ON CONSUMPTION OF ORANGE-FLESHED SWEETPOTATO AMONG YOUNG CHILDREN AND THEIR CAREGIVERS IN HOMA BAY COUNTY, KENYA

BASELINE DATA QUESTIONNAIRE: CAREGIVER'S QUESTIONNAIRE

Informed Consent

Thank you for the opportunity to speak to you. We are a group of researchers from the University of Nairobi (UoN) and the International Potato Center (CIP). We are currently conducting a study to assess the perception and effects of nutrition information dissemination approaches on consumption of sweetpotato tubers in Homa Bay County; several households will be interviewed. You have been randomly selected to participate in this study. The information you provide will help improve the understanding of the effects of nutrition information platforms on people's food consumption behavior. The interview will take around 15 to 25 minutes. Your participation is totally voluntary. You can decide to end the interview at any time or not answer any question you do not want to. Your lack of participation will not have any negative consequences on you. However, we would be very grateful if you could complete the interview.

In addition, we would like to seek your permission to allow us engage your ECD child in this study through their class teacher. We will ask them about what they ate the previous day and mark in a register on every school day. We will also do interviews with other parents/caregivers of pupils between 5-6 years old who are registered in this and other ECD centers in Homa Bay County. The responses you provide will be combined with those of others and reported together. None of your personal information will be revealed or reported.

If you may have any questions about the study now or in the future, please feel free to contact Dr. Penina Muoki (Tel. 0706284877) of CIP or Dr. David Jakinda (Tel. 0727405399) of University of Nairobi.

If you may permit me, I would now like to start the interview. May I proceed? Yes …… No ……

Respondent Screening Questions

i. Do you have a child in [name] ECD center? 1= Yes, 0=No [*If **No,** terminate the interview*]
ii. Did you get the OFSP vines during the last planting season from any source? 1= Yes, 0=No [*If **No,** terminate the interview*]

Questionnaire Identification

1. Date……..Start time ……..…… End time ……
2. Questionnaire Unique ID No……... Study treatment/sub-group...……...…….
3. Name of enumerator…….....
4. Name of the ECD center ……Sub-County ……...
[*Enumerator please ensure that each child is represented by one caregiver and both should be members of a single household. In case the caregiver has two kids in the ECD center (i.e two children from one household), the older of the two will be the focus of the questionnaire and recruited for the dietary diversity register responses.*]
5. Name of the child……Grade……Age……...…..
6. Name of the caregiver ……..……..……..…….
7. Respondents mobile contact ……..……...

PART A. OFSP AWARENESS AND UTILIZATION

1. Have you ever heard of Orange-Fleshed Sweet Potato (OFSP)? [*Dholuo version of OFSP is* "***Rabuon ma iye ratong' ma ohoore***"] **1**=Yes, **0**=No

2. If **yes to Q2**, who/where did you hear it from? **1**=Neighbor, **2**=Market center, **3**=Clinical visits, **4**=Cooking demonstrations, **5**=School children, **6**= Radio/TV spots, **7**= Others [*specify*] ..... **99**=N/A

3. Are you currently growing OFSP? **1**=Yes, **0**=No [Skip to Q6]

4. If **yes to Q3**, where did you get the vines from?
1=CIP/project 2=Neighbor/friend 3= Other (specify)……. **99**=N/A

5. When did you first grow OFSP? Month ……. Year …….

6. Have you ever cooked OFSP for your family? **1**=Yes, **0**=No

7. If **yes to Q6**, when did you first cook the OFSP root for your family?
……..……...**99**=N/A

8. Which are your **most** preferred methods of cooking OFSP? [Click all that apply]
1=Boiling, **2**=Roasting, **3**=Prepare chapatti/mandazi, **4**=Mixing in other food stuffs (*githeri/nyoyo*), **5**=Others…… **99**=N/A

9. How many times on average do you cook OFSP in a week?
……

10. Have you ever fed [name of the child] on OFSP foods? **1**=Yes, **0**=No

11. If **yes to Q9**, when did you first feed them on the OFSP foods? month……year……
99=N/A

12. If you feed OFSP foods to your child please indicate why?
1=Contains Vitamin **2**=Good for health **3**=Good for eye sight 4=Good for immunity
5=Good for children **6**=Good for men/women **8**=Do not know **99**=N/A

13. How many times in the last one week has your child eaten OFSP foods?
…….

PART B. INSTITUTIONAL FACTORS

1.	What is the distance from your home to the nearest market? …….. [*Specify distance in walking minutes*]
2.	What is the distance from your home to the nearest health facility? …….. [*Specify distance in walking minutes*]
3.	What is the distance from your home to the nearest community health volunteer? ……[*Specify distance in walking minutes*]
4.	In most cases, how do you obtain the sweetpotatoes that are cooked in your house? **1**= Purchase from the market, **2**= Harvest from my farm, **3**= Acquire from a neighbor/friend/colleague's farm, **4**= Other [*specify*] …… **99**=N/A
5.	Is OFSP sold in your nearest market? 1=Yes, **0**=No, **8**=Do not know
6.	If **yes to Q3**, how many times in a week do you find OFSP in your nearest market, when sweetpotatois in season? **1**=Once, **2**=2 times, **3**=3times, **4**=4 times, **5**=5 times, **6**=6 times, **7**=Everyday, **99**=N/A
7.	If **yes to Q3**, how many times in a week do you find OFSP in your nearest market, when sweetpotatois NOT in season? **1**=Once, **2**=2 times, **3**=3times, **4**=4 times, **5**=5 times, **6**=6 times, **7**=Everyday, **99**=N/A
8.	How involved are you in making the following decisions in the household? [*Please use the scale: **0**=Not involved at all, **1**=Little involvement, **2**=Some involvement, **3**=Make almost all decisions, and **4**=Make all decisions*] i. Allocating money for purchase of food …… ii. Amount of food to prepare in the house …….. iii. What food type is bought and or prepared in the house …….
9.	Are you aware of any traditional belief associated with OFSP consumption? **1**=Yes, **0**= No
10.	If **yes to Q9**, what do the beliefs say? …… ……**99**=N/A
11.	Which of these beliefs **in Q10** do you yourself believe?

	.... **99**=N/A
12.	If **yes to Q9,** From your honest assessment, why do you believe it? Because… 1= I have been told, **2**=It is traditional, **3**=Myself I have imagined it, **4**=I have an actual experience of the same.
13.	What is the type of the floor of your house? **0**=Mud/local soil, **1**=Cement, **2**=Tiles
14.	What is the type of the wall of your house? **0**=Mud/Local soil, **1**= Iron sheet, **2**= Brick
15.	Which information and communication devices do you use frequently [Circle all that apply] **1**=Radio, **2**=Television, **3**=Mobile phone, **4**=Computer, **5**=Others (specify) ……..
16.	Who **mostly** decides what food is purchased in the house? **1**=Father, **2**=Mother, **3**=Grandfather, **4**=Grandmother, **5**=Housemaid, **6**=Other
17.	Who **mostly** decides what food is prepared in the house? **1**=Father, **2**=Mother, **3**=Grandfather, **4**=Grandmother, **5**=Housemaid, **6**=Other
18.	Do the children influence decision on the food purchased? **1**=Yes, **0**=No
19.	Do the children influence decision on the food that is planted? **1**=Yes, **0**=No
20.	Do the children influence decision on the food that is prepared in the household? **1**=Yes, **0**=No
21.	Are you currently growing white/yellow-fleshed sweetpotato types? **1**=Yes, **0**=No
22.	If **yes to Q14**, when do you expect to harvest this for HH consumption? **1**=Currently harvesting, **2**=1 week from now, **3**=2 weeks from now, **4**=3 weeks from now, **5**=4 weeks from now, **6**= More than 4 weeks from now, **99**=N/A
23.	On average at what price does a normal and common bundle/bunch/heap of the following go? **16A**. OFSP roots …… **16 B**. Yellow/white-fleshed sweetpotato roots ……

PART C. DIETARY DIVERSITY

Instructions for collecting data on 24-hour dietary diversity:

Now I'd like to ask you to describe everything that [name of ECD child] ate or drank yesterday during the day or night, whether he/she ate it at home or anywhere else. Please include all foods and drinks, any snacks or small meals, as well as any main meals. Remember to include all foods you may have eaten while preparing meals or preparing food for others. Please also include food you ate even if it was eaten elsewhere, away from your home. Let's start with the first food or drink consumed yesterday after waking up.

[*Enumerator: Caregiver refers to a woman/man that is responsible for the care of [name of ECD child] in the household. Start the interview by asking: "Did you have anything to eat or drink when you woke up? If yes, what? Anything else? Next ask "Did you have anything to eat or drink later in the morning? If yes, what? Anything else? Continue until bed time*]

#		Question	ECD Child

	Food Group	**Name of the respondent……..... HHID……**	*[1=Yes 0=No]*
1	Cereals	Any starchy foods like bread,noodles,orproducts madefrommillet,sorghum, barley, maize,rice,wheat+*insert localfoodse.g. ugali,porridge (uji)orpastesorother locallyavailablegrains* staple,	
2	Whitetubers & roots	Any whitepotato,whiteyams,cassava, arrow roots orfoodsmade from these	
3	biofortified foods	A type of sweetpotato that is orange inside or orange maize or beans with Iron content	
4	Legumes	Any beans or peas, including soybeans, green-gram, Phil-beans.	
5	Nut and seeds	Any nuts, groundnuts or cashews or seeds like pumpkins or sunflower, sesame	
6	Milk & milk products	Any dairy products like milk, yoghurt or cheese or other milk products	
7	Organ meat	Any organ meat like liver, gizzards, lungs, kidneys or heart or other organ meats or blood based foods. e.g Matumbo,	
8	Flesh meats	Any beef,pork,lamb,goat,rabbit,wildgame,chicken, duck,orotherbirds	
9	Edible insects	Any termites, crickets, locust, white ants, or nsenene	
10	Eggs	Any eggs	
11	Fish	Any kind of fish, fresh or dried	
12	Dark green leafy vegetables	Any darkgreen/leafyvegetables,includingwildones+ *locallyavailablevitamin-Arichleavessuchascassava leaves, sukumawiki, nakati, dod(Amaranth), Spinach, Black-night shed, Pumpkin leaves,etc.*	
13	Other vegetables	Any othervegetables(e.g.tomato,onion,eggplant), includingwildvegetables	
14	Vitamin A rich vegetables	Any pumpkin,carrots,squash, locally available ((bio)fortified) orange and yellow flesh sweetpotato+ *otherlocallyavailablevitamin-Arich vegetables*	

15	Vitamin A rich fruits	Any ripemangoes,cantaloupe,ripepapaya *+otherlocallyavailablevitaminA-richfruits*	
16	Other fruits	Any other kind of fruits e.g., orange, banana, guava, including wild fruits,	
17	Oils and fats	Any source of fat, lard, like cooking oil, coconut milk, or butter	
18	Sweets	Any sugary foods or drinks like sugar,honey,sweetenedsodaorsugaryfoodssuch aschocolates,cookies, candies, biscuits,cookies	
19	Spices & condiments	Like spices (blackpepper,salt),condiments(soysauce,hot sauce),coffee,tea,alcoholicbeveragesOR*local examples*	

PART D. FREQUENCY OF CONSUMPTION OF VITAMIN A RICH FOOD AND MAJOR FOOD GROUPS DURING THE PAST 7 DAYS

Now we have a few more questions on how often your child [name of the child] has eaten certain food during the past 7 days.

[*Enumerator, please explain to the respondent that you are interested in the number of DAYS, not the number of times. That is, if the food is eaten at lunch and at dinner on the same day it still counts as 1 day. Also remember that the food can be part of other foods served. E.g milk added to maize flour in porridge, maize and beans in githeri/nyoyo*]

During the past seven days, how many days did the child eat …….. [*name of food*]? How many days, starting with the last day [*specify the day*], did the child eat [*name of food*]?

Number of days the food was consumed over the past seven days. [*Please insert the values in the provided cells*]

#	Food name	Child	#	Food name	Child
1	Main staple (Maize, rice, cassava etc)		**17**	Egg with yolk	
2	Whole chillies or hot pepper		**18**	Any fish Fresh (with intact leaver	
3	Dark green leaves		**19**	Liver-from any animal or bird (e.g. chicken) or fish	
4	Pumpkin leaves		**20**	Meat from cow/pig/sheep/rabbit/chickens or wild game	
5	Sweet potato leaves		**21**	Butter	
6	Amaranth leaves		**22**	Cod liver oil	
7	Red Palm oil		**23**	Food fried in oil or with oil	

8	Milk or milk product (cheese, yoghurt)		**24**	Passion fruit for other fruit rich in vitamin A	
9	Carrots		**25**	Vitamin A fortified magarine (BLUEBAND) or oil	
10	Ripe mango fresh as a juice		**26**	Chicken or other poultry	
11	Pumpkin or Orange squash		**27**	Weaning food fortified with vitamin A, like Cerelac	
12	Ripe papaya, fresh or as juice		**28**	Infant formula (e.g NAN etc) fortified with vitamin A	
13	Wheat Biscuits Cookies Bread		**29**	Coconut milk or oil, cooking oil ghee	
14	White-Fleshed sweetpotato		**30**	Any sugar to which vitamin A has been added	
15	Orange-Fleshed Sweet potato		**31**	Beans (all kinds0, peas, lentils other legumes	
16	Yellow-fleshed sweetpotato		**32**	Groundnut, cashew nut or any other nut	

33	If the child ate any type of sweetpotato: On a typical day how many roots does the child eat during the entire day?	
	33A Number of roots	**33B.** Size (show pictures of the sizes) **1**=Very-small, **2**=Small, **3**=Medium, **4**=Large
34	If the child consumed sweetpotato: On any day that the child eats Sweet potato is it for; [Use the scale: ***0***=*No*, ***1***=*Yes*, ***8***=*Do not know*]	
	34A. Snack ……. **34B.** Breakfast ……. **34C.** Lunch …….. **34D.** Supper/Dinner ……..	

PART E. HOUSEHOLD FOOD INSECURITY ACCESS SCALE (HFIAS)

Kindly complete the table below regarding food security situation in your household, in the last four weeks**.**

#	**HFIAS Question**	Response **1=Yes, 0=No**	If **yes**, how often **in the past 4 weeks?** **1**= 1-2 times **2**= 3-10 times **3**= >10 times
1	In the past four weeks, did you worry that your household would not have enough food?		
2	In the past four weeks, were you or any household member not able **to eat the kinds of food you preferred** due to lack of resources?		
3	In the past four weeks, did you or any household member have to eat **a limited variety** of foods due to lack of means to buy them?		
4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?		

5	In the past four weeks, did you or any household member have to eat **a smaller meal** than you felt you needed because there was not enough food?		
6	In the past four weeks, did you or any other household member have to eat **fewer meals** in a day because there was not enough food?		
7	In the past four weeks, was their **ever (a day when there was) no food** to eat of **any kind** in your household because of lack of resources to get food?		
8	In the past four weeks, did you or any other household member have to sleep at night hungry because there was not enough food?		
9	In the past four weeks, did you or any other household member go the whole day and night without eating anything because there was not enough food?		

PART F: OFSP KNOWLEDGE, ATTITUDE AND PRACTICES (KAP)

[*Enumerator please read*]: Please judge/assess the OFSP whose vine was provided to you at the ECD center against the following series of descriptive scales according to how YOU perceive the product as you had it for the first time:
Make each item a separate and independent judgment. Work at fairly high speed through the set of scales. Do not worry or puzzle over individual items. It is your first impressions, i.e., the immediate feelings about the items that we want. On the other hand, please do not be careless, because we want your true impressions.

FA: KNOWLEDGE

FA: KNOWLEDGE

Objective Knowledge			
[*Enumerator: Please explain to the respondent that for the following questions he is to respond with a "True," "False" or "I don't know."*] *Tick as appropriate*	**True**	**False**	**I Don't Know**
Question 1: Knowledge on OFSP Production			
1.1 Orange fleshed sweetpotato matures faster than the white and yellow fleshed sweetpotato			
1.2 Sweet potato does not yield well if planted at the onset of the rains			
1.3 Orange fleshed sweetpotato is an important source of vitamin A			
1.4 Vitamin A needs of pregnant and breastfeeding women is higher than for other women even of the same age.			
1.5 The cost and labor involved in producing Orange fleshed sweetpotato is similar to the cost and labor involved in producing either white or yellow fleshed sweetpotatoes			
1.6 Orange fleshed sweetpotato is planted just like the other sweetpotato varieties (white and yellow fleshed)			
1.7 Sweet potato weevils cause holes in sweetpotato roots			
1.8 It is okay to plant sweetpotato on the same plot/space consecutively for two or more rain season			
1.9Orange fleshed sweetpotato vines are sold just like any other seeds			
1.10Sweet potato is recommended for planting in Kitchen gardens *(Enumerator: Please explain that a kitchen garden is a small plot in homestead for growing food crops normally not for sale.)*			
Question 2: Knowledge on OFSP consumption			
2.1 OFSP is meant to be enjoyed by the entire family			
2.2 OFSP can be consumed in more than one form of meal			
2.3 OFSP is consumed just like the white and yellow fleshed sweetpotato varieties			
2.4 OFSP can also be prepared in other value added forms such as Mandazi, Chapati, bread			
Question 3: Knowledge on Vitamin A			
3.1 Have you heard of Vitamin A. 1=Yes 2=No			
3.2 If yes, from what source did you first hear about vitamin A?			

3.3 What are some of the benefits of Vitamin A? *DO NOT PROMPT THE LIST*	Codes: 1. No correct answer given 2. One correct answer given 3. At least two correct answers given
Checklist: Good health *Improve our immunity* *Better eyesight* *Tissue development*	
3.4 Who needs Vitamin A most in the household? *DO NOT PROMPT THE LIST*	Codes: 1. No correct answer given

	2. One correct answer given 3. At least two correct answers given
Checklist: Women between 15 – 49 years old *The breasfeeding mothers* *Pregnant women* *Children under 5 years old*	
3.5 Please mention some of the foods consumed in your household which are not sources of Vitamin A. *DO NOT PROMPT THE LIST*	Codes: 1. No vitamin A food known or identified 2. One vitamin A food identified 3. Two vitamin A foods identified 4. Three vitamin A foods identified
Checklist: Dark green vegetables Eggs *Fruits* *Orange fleshed fruits* *Orange fleshed sweetpotatoes* *Yellow vegetables* *Milk and milk products*	

FB: ATTITUDE						
Question 4: Specific attitudes						
Scale: 1= Strongly disagree; 2=Disagree; 3=Neither Agree nor Disagree; 4=Agree; 5=Strongly Agree						
Please state the level to which you agree/disagree with the following statements:	**1**	**2**	**3**	**4**	**5**	
4.1 The orange colour of Vitamin A sweetpotato is not appealing to me						
4.2 Orange fleshed sweetpotato requires advanced skills to plant						
4.3 Most people I know are not aware of orange-fleshed sweetpotato						
4.4 Orange fleshed sweetpotato has a bad taste						
4.5 Orange fleshed sweetpotato is only meant for children						
4.6 Orange fleshed sweetpotato is served only as a snack or at breakfast						
4.7 Sweet potato should not be served as main meal either for lunch or dinner						
4.8 There is no other way you can prepare OFSP root other than steaming it.						
4.9 Most people I know prefer white/yellow-fleshed sweetpotato to OFSP and would prepare the former if both are present.						
4.10 During a workshop in Kisumu, people were advised that "we should eat OFSP since it is good for our health." How do you agree with this statement?						

4.11 "Sweet potato is typically meant for the poor, it is the reason the rich eat very small amounts of it." How do you agree with this statement?						

4.12 Do you agree with the statement that compared to other sweetpotato types OFSP is (of):	Yes	No	Neutral	Don't Know
1. Higher Yield				
2. Yield				
3. Early maturity				
4. Resistance to diseases				
5. Resistance to drought				
6. Marketability				
7. Taste				
8. Nutritional Value				

FC: PRACTICE

Question 5: Practice

[*Enumerator: Please explain to the respondent that for the following questions he is to respond with a "**Yes**" or "**No**"*] *Tick as appropriate*	**Yes**	**No**
5.1 I plant Orange fleshed sweetpotato as a Cash crop		
5.2 I plant Orange fleshed sweetpotato as a FOOD crop		
5.3 I do preserve the vines under the ground in preparation for their next planting.		
5.4 I market OFSP just like any other sweetpotato		
5.5 Sweet potato can only be cooked through roasting, boiling, frying or eaten in raw form		
5.6 I have since increased the amount of OFSP eaten by my household		
5.7 I have sourced more vines from other sweetpotato oriented organizations		
5.8 This season, I have shared some of the vines from my plot with my neighbors		
5.9 In how many ways have you prepared OFSP? 1 2 3 4 5		
5.10 Please state the forms in which you have prepared OFSP. ……..		
5.11 I will plant OFSP as a cash crop in the new season.		
5.12 I will continue to plant OFSP as a food crop in the new season.		
5.13 I prepared a fresh piece of land for OFSP production.		
5.14 I have rented a piece of land for OFSP production.		
5.15 All people of my household are fed on OFSP		
5.16 I sold a portion of my harvest of OFSP roots to buyers in the local market		

5.17 We have formed/joined an OFSP farmers group					
5.18 I have advised my friends and neighbors to plant OFSP					
5.19 What is the size of the farm on OFSP?					
6.1 If I am to stop growing OFSP it would be because of	Yes	No	6.2 If I am to continue growing OFSP it would be because of	Yes	No
1. Poor yields			1. Good yields		
2. Susceptibility to diseases			2. Resistance to diseases		
3. Poor marketability			3. Good marketability		
4. Susceptibility to drought			4. Resistance to drought		
5. Lack of vines			5. Availability of vines		
6. Spouse objects or prohibits			6. Spouse allows or promotes		
7. No strong reason to stop as yet			7. No strong reason to stop yet		
8. A longer maturity period			8. A shorter maturity period		
9. Other (specify)			9. Other (specify)		

PART H. BACKGROUND

Please complete the table below about yourself and your household

1.	Gender	**1**=Male, **0**=Female		**2 .** Age (*years*)	… …		
3.	Marital Status	**1**=Never married, **2**=Married, living with spouse **3**=Married, spouse lives elsewhere **4**=Separated, **5**= Widow/Widower					
4.	Relationship to the HH head	**1**= Self, **2**=Spouse, **3**=Son/Daughter, **4**=Niece/Nephew, **5**=Other ……					
5.	Relationship to the child	**1**=Mother, **2**=Father, **3**=Grandfather/mother, **4**=Aunt, **5**=Other…….					
6.	Occupation	**1**=Farmer, **2**=Farm salaried employment, **3**=Non-farm salaried employment, **4**=Trader/Business, **5**=Casual non-farm employment **6**=Casual farm employment **7**=Other *(specify)*……					
7.	Occupation of HH head	**1**=Farmer, **2**=Farm salaried employment, **3**=Non-farm salaried employment, **4**=Trader/Business, **5**=Casual non-farm employment **6**=Casual farm employment **7**=Other *(specify)*……					
8.	Education (years of schooling)	…….					
9.	Please indicate your expected amounts of income per month from the following as applies to you (in Kshs.)	**1**=Business	… ….	**2**=Farm output sales	… …..	**3=**Remittances	…… …
		4=Pension	… ….	**5**=Full-time salary	… …..	**6**=Part-time salary	…… ….
		7=Others (*specify*) ……..……					

10.	Kindly give your estimated monthly expenditure on the following (in KShs.).	i. Food	….	ii. Clothing	….	iii. Health & Medication	…… ….
		iv. Transport	….	v. Communication	….	vi. Housing	…… ….
		vii. Education	….	viii. Entertainment	….	ix. Security	…… ….
		x. Other (*specify* …….					
11.	Total number of persons in the HH	……					
12.	How many people in the HH are:	i. <6 months		ii. 6-23 months		iii. 24 months to 5 yrs	
		iv. >5 years		v. Breastfeeding		vi. Pregnant	

THANK YOU

Appendix C: Dietary Diversity Register

Appendix D: Estimation of OFSP Consumption Data with more Covariates

Appendix D1: Extended models for estimating the probability and frequency of OFSP consumption

Dependent variable =	(1) Consume	(2) Consume	(3) Consumption frequency	(4) Consumption frequency	(5) Consume ≥1 per week	(6) Consume ≥1 per week
	Binary Logit		ZIP		Binary Logit	
	Coef	dy/dx	Coef.	dy/dx	Coef.	dy/dx
Main						
PT	0.484	0.0431	0.202	0.266	0.635	0.0201
	(0.792)	(0.761)	(0.298)	(0.342)	(0.458)	(0.529)
IT	1.059	0.0985	0.485***	0.743**	2.938***	0.193**
	(0.577)	(0.475)	(0.007)	(0.033)	(0.006)	(0.027)
CT	0.368	0.0326	0.161	0.208	1.923**	0.0955*
	(0.836)	(0.825)	(0.169)	(0.177)	(0.042)	(0.079)
Child's Age	-0.0778	-0.0075	0.0302	0.0435	0.413**	0.0241**
	(0.775)	(0.785)	(0.512)	(0.519)	(0.036)	(0.043)
Child's Gender	0.139	0.0135	0.0586	0.0844	-0.654	-0.0381
	(0.730)	(0.737)	(0.388)	(0.402)	(0.113)	(0.120)
Caregiver's AGE	-0.0065	-0.0006	0.0003	0.0004	-0.0400*	-0.0023*
	(0.719)	(0.718)	(0.934)	(0.934)	(0.093)	(0.081)
Caregivers	0.445	0.0431	0.0692	0.0997	-0.577	-0.0336
Education	(0.421)	(0.424)	(0.177)	(0.202)	(0.329)	(0.324)
Caregiver is HHH	-0.185	-0.0180	0.0182	0.0263	0.518	0.0302
	(0.655)	(0.668)	(0.836)	(0.835)	(0.231)	(0.201)
Marital status	-0.0292	-0.00283	0.244	0.351	1.024	0.0597
	(0.968)	(0.968)	(0.164)	(0.183)	(0.191)	(0.206)
Member of a	0.373	0.0362	0.172**	0.247**	1.089*	0.0635
farmers' group	(0.312)	(0.323)	(0.023)	(0.043)	(0.095)	(0.107)
Knowledge of	0.172	0.0167	-0.173	-0.250	-1.633**	-0.0952***
Vitamin A	(0.829)	(0.832)	(0.302)	(0.321)	(0.013)	(0.003)
(baseline)						
Attitude towards	-0.298	-0.0289	0.235	0.339	0.393	0.0229
OFSP(baseline)	(0.898)	(0.897)	(0.495)	(0.500)	(0.880)	(0.880)
HH has under-5	-0.195	-0.0189	0.147	0.212	0.179	0.0104
y/o	(0.703)	(0.698)	(0.129)	(0.148)	(0.858)	(0.858)
HH Size	-0.0990	-0.00959	0.0411	0.0592	1.350*	0.0787*
	(0.836)	(0.840)	(0.568)	(0.566)	(0.078)	(0.053)
Distance to HF	-0.0481	-0.00466	0.0453*	0.0653*	0.246	0.0143
	(0.704)	(0.699)	(0.070)	(0.089)	(0.127)	(0.126)
Distance to CHV	0.00162	0.000157	-0.0115	-0.0166	-0.150	-0.0088

Dependent variable =	(1) Consume	(2)	(3) Consumption frequency	(4)	(5) Consume ≥1 per week	(6)
	Binary Logit		ZIP		Binary Logit	
	Coef	dy/dx	Coef.	dy/dx	Coef.	dy/dx
	(0.991)	(0.991)	(0.640)	(0.639)	(0.313)	(0.293)
Produced OFSP	4.523***	0.438***	1.708***	3.092	3.873***	0.226***
	(0.008)	(0.000)	(0.000)	(0.102)	(0.000)	(0.000)
Monthly	-0.347*	-0.0336	0.0151	-0.0351	0.124	0.0073
expenditure (log)	(0.060)	(0.107)	(0.743)	(0.635)	(0.740)	(0.740)
Constant	2.387		-5.111***		-14.06***	
	(0.567)		(0.000)		(0.000)	
Inflate						
Produced OFSP (*dummy*)			-27.45**			
			(0.024)			
Monthly Expenditure (*logged*)			2.469			
			(0.802)			
Constant			-22.07			
			(0.817)			
Observations	373	373	373	373	373	373
Chi-square	34.06		139.7		151.8	
p-value	0.0124		7.21e-21		3.39e-23	
Log-likelihood	-120.9		-460.5		-72.76	
AIC	279.8	.	964.9	.	183.5	.
BIC	354.3	.	1051.2	.	258.0	.
Cluster variable	village		village		village	
VCE	bootstrap	delta	bootstrap	delta	bootstrap	delta

Notes: Columns (1), (3) and (5) presents the coefficient estimates for the respective models; columns (2), (4) and (6) present the Average Marginal Effects after estimating the respective models. *p*-values in parentheses. All model estimates include village fixed effects due to clustering at village levels. The ZIP model estimation were exposed to the variable *present*- (the total number of days that the child turned up to the ECD center/school). Unlike in Table 10, the *p*-values are adjusted using *bootstrap-t* procedure due to few clusters (15) relative to the estimated parameters (23) (Roodman et al., 2019).

* p<0.10, ** p<0.05, *** p<0.01

Source: Survey Data 2018

Appendix D2: Model specification for estimating the likelihood and frequency of OFSP consumption

The effect of the randomization variables on the probability and/or frequency of consumption of OFSP were estimated while controlling for a set of variables supported by literature on OFSP consumption. The estimates control for preschoolers' (sex and age), caregivers' (age, education, main livelihood source, knowledge of vitamin A and benefits, attitude towards OFSP and relationship to household head, marital status, and membership to a local farmers' group), household (size, presence of an under-5 year old, travel time to the nearest health facility, and travel time to the nearest community health volunteer) and village level fixed effects. All the 14 control variables are included in the replicate models in *Appendix D*. However, for brevity and better model fit, only 7 controls are included in Table 10 above. A Spearman's correlation test was used to select a set of the variables which were significantly correlated to the dependent variable - frequency of OFSP consumption - at 30 percent level of significance. Table 10 models are preferred to the models in *Appendix D1* given the statistical evidence that they have better goodness of fit (a higher Log-likelihood, and smaller AIC and BIC statistics) relative to the *Appendix D1* above. An omitted variable test for the specification in Table 10, column (3) yielded non-significant at 5 percent level of significance (F (3, 362) = 2.48; p-value= 0.0605), implying that there is no significant statistical evidence that the model is under-specified. In addition a variance inflation factor test for multicollinearity confirmed that there were no elements of multicollinearity within the specified regressors (VIF = 1.02).