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Research Article

A Multisectoral Approach to Eradication of Malnutrition in Vulnerable Groups: A Cluster-randomized Trial

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Abstract

Nutrition is essential for sustainable development and a cornerstone for the achievement of all the Sustainable Development Goals. Yet, malnutrition is still a challenge in Uganda especially among the vulnerable groups – pregnant women, lactating mothers, adolescents and children below 5 years of age. Malnutrition being a multidisciplinary issue, it requires a multisectoral approach for it to be addressed. This paper examines an integrated approach to improving food security and nutrition of children below 5 years old by increasing smallholders' production and consumption of nutrient-rich staple crops in Uganda. The study was conducted in the districts of Ibanda, Sheema, Kalungu and Kyotera in southwestern Uganda using a cluster-randomized controlled design. 180 villages were randomly assigned to six treatment groups (30 villages per treatment group) and 30 villages were assigned to a control group. The results of the follow-up evaluation that was conducted two years after the baseline survey showed a statistically significant increase in food security in the treatment group that had both agricultural and health interventions and the voucher scheme for subsidized agricultural inputs. Wasting and underweight were significantly reduced in the treatment group that had agricultural and health interventions and the voucher scheme for subsidized agricultural inputs, and the treatment group with only health interventions. However, an increase in the prevalence of stunting that was significantly larger than that in the control group was noted in the treatment group that received only agricultural interventions. Hence, a contextual right mix of interventions is required, other factors remaining constant, to increase food security and reduce malnutrition among the vulnerable groups.

Keywords: Children; Malnutrition; Nutrition

Introduction

Malnutrition is a serious global development challenge. Worldwide, malnutrition is responsible for nearly 50% of deaths among children under the age of 5 years, and it has been steadily increasing in most countries. A lack of adequate nutrition affects mainly children and pregnant mothers and can result in mal-development of the brain, leading to medium and long term negative mental and health outcomes. For mothers, this is usually as a result of Intrauterine Growth Restriction (IUGR) and low birth weight (LBW). It is also revealed through the prevalence of stunting and wasting in children under 5 years old. These conditions manifest as inadequate weight and height attainment for children within particular age ranges. Other common malnutrition related conditions include Vitamin-A deficiency (VAD) and xeropthalmia. The occurrence of global malnutrition is linked intricately to household behavior in relation to the choice of foods consumed as well as geo-climatic stress conditions. Malnutrition and its related conditions are experienced most especially in South-Central Asia, South America, Northern and Sub-Saharan Africa. It is estimated that over 2 billion children are affected by malnutrition and related complications [1]. Aside from its negative effects on growth and development, it is also associated with high diarrhea prevalence which is another factor that contributes to the high child mortality rates. Numerous strategies have been applied to alleviate the situation including the promotion of breast feeding, dietary supplementation of micronutrients in form of tablets or injectables, sensitization and the bio-fortification of foods, with some strategies proving to be more successful than others.

The use of bio-fortified foods and supplements has been proven to be quite effective as a means of improving nutrient intake [2-5]. The promotion of breast feeding, dietary supplementation, and improving the standards of hygiene of available weaning foods provided as a full package could reduce malnutrition related deaths by one quarter for children under 36 months. However, such systems that rely on strong health systems and behavioral change do not seem to have as much success [1,6,7]. The use of intravenous delivery of micronutrients for instance requires the presence of sufficient health infrastructure and personnel to be able to cover large areas. Besides, it is quite costly to implement especially in areas that lack the expertise.

Fortified food nutrition has therefore emerged as a practical, yet affordable, way of promoting food security and increasing intake of important micronutrients of which rates of micro nutrient deficiency are quite high. Sub Saharan Africa, which is predominantly agrarian and where in many areas, especially rural, there exist few amenities or infrastructure to deliver micronutrients using contemporary methods, bio-fortification has the potential to increase essential nutrient intake. The specificity of targeted interventions therefore requires innovative, practical solutions that can model behavior in the right direction. There have been mild successes in the reduction rates of stunting in Ethiopia, Ghana and Mauritania, but by and large, the stunting rates have remained stagnated and, on some occasions, more severe [8]. In Uganda, the prevalence rates of malnutrition are high especially in the South-Western region. Indeed, 60 percent of the children under 5 years in this region fall 2 or 3 Standard Deviations below the median WHO Child Growth Standards height compared to the national average of only 47 percent [9], indicating disproportionately high stunting in the region. This results from a number of factors with poor feeding habits and behavioral norms contributing most to the status quo. For instance, breastfeeding practice for new mothers is many a time poorly enforced resulting in early stage underdevelopment among infants. Improper nutrition among pregnant mothers is another challenge that afflicts many to-be mothers. The Ministry of health for instance and numerous entities that engage with pre and post natal care promote the consumption of nutrient rich foods, many of which are beyond the reach of a rural mother, owing to the high cost of these foods thus increasing the mother's risk of experiencing Intrauterine Growth Restriction. This aspect highlights poverty as another contributor to malnutrition.

Agriculture is one of Uganda's primary growth sectors due to the fact that subsistence farming by smallholders accounts for 96% of all agricultural production, 25% of the total Gross Domestic Product, employs over two-thirds of the country's workforce, and earns over 40 percent of household income. However, the country is reeling from poverty: rural poverty is three times higher (27%) than urban poverty (9%), and subsistence farmers suffer the highest poverty rate [10].

Hence, the Agriculture Sector Development Strategy and Investment Plan (DSIP) [11] aims to increase rural incomes and livelihoods, and improve household food and nutrition security.

Since malnutrition and poverty affect mostly pregnant women and children younger than 5 years, the pilot study tested Uganda's National Action Plan [12], which recommends a multisectoral approach, to eradicate malnutrition in these population categories. It examined the effects of financial products and agricultural and health extension services on food security and nutrition of smallholder farmers. Besides poverty alleviation (Sustainable Development Goal one), the results contribute towards the achievement of Sustainable Development Goals two – zero hunger – and three – good health and wellbeing.

Literature Review

Under- and malnutrition in Sub-Saharan Africa is characterized commonly by vitamin A, iron and iodine deficiencies. It is estimated that globally, over 2 billion people are affected by one of these three deficiencies [13]. These collectively, in addition to other micro-nutrient deficiencies, are responsible for the high rates of stunting, wasting and numerous other nutrition conditions. It is estimated that over a half of the population of children less than 5 years old in Uganda is affected by one form or another of mineral deficiency [14]. The stunting prevalence in Uganda is estimated to be about 29% for children aged less than 5 years old. In addition, the prevalence of underweight stands at 11% of the population in the same demographic [14]. Stunting particularly has been documented to be very difficult to address as a health issue for numerous reasons. This is because, aside from the fact that it is associated with poor nutrition, it is attributed to poor nutritional choices and genetic predispositions among others [15]. For instance, in south western Uganda which has the highest rates of stunting and wasting in Uganda, Matooke (plantains) is the main source of nutrients which are not as nutritious as other food alternatives in the same food group. This has been compounded by the fact that improved varieties do not contain sufficient essential micro and macro nutrients and the nutritional quality of plantain has been diminishing over time with soil exhaustion. The presence of malnutrition in itself is not exclusive of environmental, demographic and other factors. The prevalence of stunting and wasting have been identified to be associated with a number of factors ranging from low mothers' education, increasing age, gender, prolonged breast feeding, socio economic status, source of drinking water, birth weight and urbanicity [16].

Poor nutrition is associated with numerous medium to long term negative outcomes including cellular functioning, impaired cognitive abilities, reproductive health and work capacity [17,18] as well as numerous conditions and ailments.

The social and economic cost is therefore quite high which has accorded it the significance as a problem of epidemic proportions. Less disruptive options that can help to alleviate this situation are therefore integral to any interventions that aim to address nutritional issues. The use of food fortification has in the past many decades been hailed as a cost effective way to improve health outcomes among populations at risk of nutritional deficiency related conditions. The forms and modes in which they are delivered are varied, ranging from intensive methods that use bioprocessing techniques, to mass and focused fortification programs. As an intervention, there is a plethora of empirical evidence suggesting that it is a viable remedy to numerous under nutrition problems. It has been attributed to the effective reduction of diseases such as beriberi, pellagra, goiter and rickets; but is nowadays more prominently used to address low dietary intake problems rather than a diagnosable condition [19]. Other basic, practical and logical interventions like breastfeeding and maintaining the hygiene of available weaning foods have, in the past, also been previously applied [1] although it is important to note that interventions that rely on behavioral change and strong systems have stalled at about 30-50%. Hygiene is critical as poor hygiene increases diarrhea prevalence which coexists with malnutrition deficiencies and therefore aggravates the malnutrition problem.

The results of fortification strategies are quite impressive. For instance, a meta-analysis of 441 studies found that out of 15 randomized control trials, 14 showed significant impacts of the provision of vitamin D supplements on the sufficiency of vitamin D concentrations [20]. Food supplements, with or without education, was found to increase the height-to-age score by 0.41 standard deviations, management of case fatality rates reduced case fatality rates by over 55%, and essential micro nutrient provision among mothers reduced the risk of low birth weight by 16% [7,21].

The use of bio-fortification has been evidenced to have considerable benefits in improving health nutritional outcomes. They have been included into feeding regimes to address nutrition issues that affect special target groups, say students in certain age ranges that do not, or are unable to obtain sufficient nutrients. Biofortified foods are also commonly used in relief situations such as during famines and other disasters. Nutritional supplements for instance have helped to boost energy sources for severely malnourished children.

In the agricultural field setting however, the association between fortified crops and nutrition presents a different, more complex challenge, and evidence of its efficacy is scanty. Most studies on under nutrition do not focus on agricultural interventions as an alternative to addressing nutrition problems. As such, evidence is difficult to come by. A majority of them also rely on the results of heterogeneous analysis or observational studies, which is another methodological challenge [22]. Hence, any empirical evidence gathered is not entirely reliable. The little evidence that exists, however, shows some modest impacts of such interventions. A meta-analysis of 32 studies found that agricultural interventions did have effects on wasting, stunting and being underweight but not at significant levels [22]; while in Kenya, projects specifically relating to Orange Flesh Sweet Potato production and consumption registered significant increases in consumption, and some impacts on being underweight and wasting [23].

The application of food fortification in field conditions, as is found in many Sub-Saharan African countries and countries which are highly dependent on locally sustainable food systems, means that this is a practical strategy to improving household food security as well as the nutritional status of households and high nutritional risk groups, especially children. By addressing food systems, there is the potential of sustainably introducing essential nutrients into already existing food systems, or by alternatively adapting new food systems. There are, however, challenges associated with the adoption of new or improved varieties, especially in such conditions. Within East Africa, the issue of genetic modification of foods is still a very sensitive issue; more so if these foods are threatening the already existing food production systems. A number of such interventions have failed because of aesthetic and perception issues can inhibit uptake. In field environments like south western Uganda, more nuanced alternatives are appropriate especially if there are obvious benefits associated to adoption. The question of perception and knowledge is therefore critical for such an intervention to be taken up. South western Uganda in addition to the consumption of staples such as plantain also produce sweet potatoes. This is therefore an integral part of the local diet. Introducing orange flesh sweet potatoes therefore into the existing production systems is therefore a matter of presenting the benefits of take up to these households.

Food security is one of the key benefits linked to food bio-fortification strategies. In addition to the primary benefit of providing essential nutrients, improving the food security situation among households is another critical contribution that bio-fortified foods have been evidenced to have. A World Health Organisation analysis for instance showed a strong link between dietary diversity, hunger and nutrient deficiency. The link between food security and anthropometric outcomes however may not be as direct as food security relates to the ability to consume sufficient food rations of acceptable quality while anthropometric outcomes, in addition to being linked to food security are strongly associated to fortification as well. The mediation between fortification and food security is probably via the household's ability to produce more food. Sweet potatoes are high stress crops that are able to withstand drought conditions. Promoting them as a food crop therefore could plausibly be linked to higher food security.

Methodology

Research design

The study, conducted in the districts of Ibanda, Sheema, Kalungu and Kyotera in southwestern Uganda, used a cluster-randomized controlled design. 180 villages were randomly assigned to six treatment groups (30 villages per treatment group) and 30 villages were assigned to a control group.

Treatment groups were

- T1: Agriculture only, provides farmers with free inputs for nutrient rich crops – Orange Fleshed Sweet Potato vines, iron-rich beans, nutrient-rich vegetables – and agricultural training for the first one year of the intervention period.
- T2: Agriculture and Health, provides households with both agriculture and health interventions.
- T3 provides agricultural credit – to address cash constraints – on top of T2
- T4 provides the voucher scheme – to get agricultural inputs at lower prices – on top of T2
- T5 provides price insurance – to address price risk – on top of T2.
- T6: Health only provides: growth monitoring and promotion (GMP) sessions for under-2 children, quarterly health and nutrition community forums as well as conditional food transfers to pregnant women.

Sampling

Sampling was done in two phases – at the household and village levels.

At household level, a census of all households in the four districts was conducted in December 2013. Using both village data and household-level census data, six treatment arms and one control group were randomly assigned at the village level across 210 villages (clusters). These treatments were evenly distributed across 4 BRAC branches at between 50-55 villages per branch. The randomization was balanced on village-level variables such as BRAC branch, village size, market access, and access to health clinics.

The random household sampling and random assignment of villages to treatments was done in conjunction such that a highly targeted sample and a perfectly balanced randomization was generated. To ensure this, the process of household sampling, village assignment, and balance testing for 1,000 random draws was repeated, thus selecting the draw that both minimized the maximum t-statistic and contained the least number of significant differences (p-value <0.1) between treatment and control groups across the balance variables of interest. Subsequently, the final sample of 7,694 households in 210 eligible villages was selected. However, there was an attrition of 196 households (2.55%) at the follow-up, leaving data from 7,498 households in analysis. Data were collected from April to June 2014, and June to August 2016.

Inclusion criteria and study population

For eligibility and inclusion into the study, the study participants had to be households with either a pregnant woman or with at least a child under 2 years old. The household also had to have access to agricultural land and be practicing farmers. The main respondent had to be between 18 - 45 years old.

Variables

Anthropometric measurements including the height, weight and middle upper arm circumference (MUAC) for the children were taken. The standardized height-for-age, weight-for-age, weight-for-height and body mass index z-scores were then calculated using WHO's "anthro" software and STATA. The scores are calculated relative to the global reference population as well as within the study population. Dummies are also generated to identify the rates of stunting and wasting based on WHO's < 2 standard deviations cut off.

The indicators of household food security are measured using FANTA's[1] household food insecurity access scale (HFIAS). It measures the incidence and frequency of food stress events in the household, as well as the inability to access food of sufficient quality or quantity within the last one month period. A score ranging from 0 to 27 is generated in which an increasing score signifies increasing food insecurity.

Data collation

Only data for which information on anthropometric measures for children between the ages of 12-60 months was available was maintained. Excluded were inconsistent cases with mismatching baseline and midline information for the children such as name mismatches and inconsistencies in age and gender of the child. Through this process a sample of 1,456 children from the original sample of 2,439 children was retained.

Analysis and econometric model

To evaluate the impact of the project, we employ difference in difference analysis. We use a two year panel between 2014 and 2016. We use generalized linear modelling to make inferences and we report the results for a random effects regression, as well as controlling for village fixed effects. Our model is based on. The standard errors are clustered at the household level.

The main specification is

$$y_i = treat_{ij} + survey_{ij} + treat * survey_{ij} + control_{ij} + e_{ij}$$

Where "y", is the outcome of interest which is the food security score; treat, is the Treatment dummy which takes on a value of 1 for treatment, else 0; survey, is the Survey round dummy which takes on a value of 1 for midline, else 0; control, is a set of controls including age, education; i, is the subscript for 170 Household level stratum; j, represents the Village and, e, is the unexplained variance.

[1]Food and Nutrition Technical Assistance is a technical cooperation between USAID and FHI 360 to improve health and wellbeing

Results

Since all the groups were balanced for both observed and unobserved characteristics before the intervention, it means that the results show the difference-indifference compared to the control.

Household food security

In the follow-up evaluation that was conducted two years after the baseline survey, an increase in food security was observed but this was only statistically significant in group Treatment 3, the one with agricultural and health interventions as well as the voucher scheme for agricultural inputs, compared with the control.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Household Food Security Score (HFIAS)	Agric Only	A+H+C	A+H+V	A+H+I	A+H	Health Only	Control
	-1.94	-1.24	-2.17**	-0.98	-1.17	-1.07	10.5
	(1.03)	(1.07)	(0.97)	(1.08)	(1.07)	(1.12)	(0.42)
Columns 1-6 display the mean change in the treatment groups with respect to the control group. Column 7 shows the outcome in the control group. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01							

Table 1: Difference-in-Difference in Household Food Security Score (HFIAS) of the different treatment arms compared to the control arm.

Anthropometric outcomes

Regarding the anthropometric outcomes, wasting was significantly reduced, compared with the control group, in only two treatment groups: T3 and T6.

In treatment group 3, the arm with agricultural and health interventions as well as the voucher scheme for agricultural inputs, there was a 14.22% reduction (p<0.05) and in treatment group 6, the arm with only health interventions, there was a reduction of 12.3% (p<0.05).

Reduction in underweight was only statistically significant for T3, the arm with agricultural and health interventions as well as the voucher scheme for agricultural inputs. This reduction was of 14.84% (p<0.05). However, an increase in the prevalence of stunting that was significantly larger than that in the control group was noted in group Treatment group1, the arm that received only agricultural interventions. This increase was of 22.62% (p<0.05). Changes in other treatment groups did not differ significantly from those in the control group.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Anthropometric indicators	Agric Only	A+H+C	A+H+V	A+H+I	A+H	Health Only	Control
Wasting (%) < 2 SD	-2.41	-5.93	-14.22**	10.89	-9.02	-12.30**	3.54
	(7.81)	(5.98)	(6.16)	(7.37)	(7.37)	(6.13)	(2.61)
Stunting (%) < 2 SD	22.62**	-1.67	10.21	5.66	0.65	9.8	37.17
	(10.5)	(9.78)	(11)	(10.72)	(10.33)	(9.89)	(4.22)
Underweight_WAZ (%) < 2 SD	-0.2	0.09	-2.58	-0.27	-7.14	1.8	7.08
	(4.55)	(4.27)	(4.57)	(4.95)	(4.62)	(4.02)	(2.47)
Underweight_BMI (%) < 2 SD	-6.93	-9.73	-14.84**	-14.5	-8.76	-12.34	3.54
	(7.96)	(6.99)	(6.85)	(8.55)	(8.09)	(6.84)	(2.61)
Columns 1-6 display the mean change in the treatment groups with respect to the control group. Column 7 shows the outcome in the control group. Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01							

Table 2

Interpretation and discussion of results

From the results above, it can be noted that the combination of health and agricultural interventions together with the voucher scheme for subsidized agricultural inputs was generally more effective in increasing food security and reducing wasting and underweight than other treatment interventions.

It is important to note that unlike other anthropometric indicators such as wasting and underweight, stunting is influenced by other factors which are beyond the control of the project. Such factors include the genes of the children as well as diseases like HIV/AIDS. It was beyond the scope of the study to test for these factors.

However, the pilot did not achieve its objective with respect to stunting, especially in the agriculture-only treatment arm (T1). While there is a possibility that contamination in the control group may have reduced the effect of the project due to the fact that similar interventions were conducted in some of the areas where the study took place, the findings do highlight the importance of health interventions in addition to simply having enough food. More so, the voucher scheme for subsidized agricultural inputs was relatively more efficient than the other two financial products – the agricultural loan and price insurance – because the inputs were in kind and not cash, and therefore not easily diverted to other uses which are not related to the objectives of the project. Besides, the agricultural products which included fertilizers are believed to have boosted the production of nutrient-rich crops. It was very hard to monitor and ensure that the agricultural loan was used for project and not diverted to other uses such as paying school fees for the children of the households under intervention.

Conclusion

The study examined an integrated approach to improving food security and the nutrition of children below 5 years by increasing smallholders' production and consumption of nutrient-rich staple crops in Uganda.

Addressing the malnutrition challenge is mostly dependent on the ability to address the underlying conditions that contribute to it. Although malnutrition is a health-related issue especially to young children and expecting and new mothers, it requires a combination of behavioral change interventions and interventions that can improve the intake of healthy, nutritious foods. Hence, it requires an integrated multisectoral approach which involves health, agricultural and financial interventions. Nonetheless, it is important to have the right combination. Interventions that rely on the food fortification can provide a practical solution. The uptake of the production of fortified foods is a necessary pre-requisite and there is potential to introduce new varieties based on already existing staples. Combined with knowledge building interventions, it is possible to improve agricultural knowledge, attitudes and practices relating to nutrition.

The study revealed some evidence of improved dietary practices as well as improvements in food security and nutrition status. In the short to medium term, there are suggestions that a combination of better agronomic practices, increased knowledge about nutrition issues and the cultivation of fortified foods can have an impact on health and nutritional outcomes. Overall however, indications are that the eradication of malnutrition related complications is a gradual process, and it would be interesting to see whether the interventions have implications on the longer term outcomes and on the sustainability of behavioral change.

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