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Differential Effect of Agriculture Diversification on Child Nutritional Outcomes in Uganda

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ABSTRACT

This study examines the effect of differential effects of agricultural diversification on child nutritional outcomes in Uganda using the Heckman endogenous panel probit with sample selection. The results showed that agriculture diversification is key to better child nutrition outcomes. Also, women's control of farm income, high education for household heads, urban residence and access to product markets positively affect child nutritional outcomes, while male children are more prone to poor child nutritional outcomes. Thus, the government needs to design measures aimed at empowering women to own and control agricultural production assets and at the same time promote education to ensure that households have nutrient-rich foods available.

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INTRODUCTION

Despite the great strides the government of Uganda has made in its attempt to meet the targets set in the National Development Plan and the Millennium Development Goals by 2030 (Republic of Uganda, 2015), huge challenges in terms of social-economic indicators remain. Agriculture diversification practices remain key to socioeconomic transformation in developing countries. Agriculture diversification is associated with economies of scale which are expected to enhance farm productivity and overall production, which in turn is expected to improve household welfare (Fan et al., 2012). Generally, agriculture diversification practices in rural areas yield big welfare gains, and this enhances households' livelihoods who are directly dependent on agriculture for their wellbeing (Bellemare, 2017). These benefits of agriculture diversification result in improvements in household welfare and better child nutritional outcomes. In anticipation of such benefits, agriculture diversification has been adopted by Uganda like other developing countries as an agriculture development strategy. This can be pinned on the fact that diversification of agriculture activities enhances increased production and enables households to have excess products to sell for household income. Thus, household income opportunities necessitate increased agriculture diversification and the establishment of good land ownership that enables women to have access to agricultural productive assets (Alliance for a Green Revolution in Africa, AGRA, 2016). However, Jaleta et al. (2009) states that the afore-mentioned benefits to households can only be realized if the policy is implemented with clear precaution and guidance against frictions in land ownership and access to farm inputs.

IFPRI (2016) states that malnutrition is not only a concern for the Ugandan community but a global challenge with serious social and economic costs. According to IFPR (2014), globally every country is facing a serious public health challenge due to malnutrition, such that in every 3 people, 1 person is malnourished. Similarly, IFPRI (2016) states that 159 million children under the age of five years are stunted (low weight for age), and about 795 million people hungry. In that essence, World Health Organization (WHO, 2008) notes that food insecurity has unprecedented consequences. WHO (2008) document evidence of micronutrient deficiencies among 2 million people worldwide, while iron deficiency alone affects more than 1.5 million people. Interestingly, evidence by WHO (2018) shows that in Africa and Southeast Asia, two-thirds of pre-schoolers and around half of all pregnant women are anaemic. In addition, WHO (2016) states that vitamin A deficiency affects about 250 million preschool-age children and blinding up to 500,000 of them, while 250,000 children die shortly after losing their vision. In such a situation, diversification of agricultural activities as a means of increasing food production remains fundamental in ensuring food and nutrition security, an important goal of the Sustainable Development Goals (SDGs).

In addition, WHO (2016) states that globally 45% of all deaths of children under five years of age is due to malnutrition, and this is over 3 million deaths each year. The consequences of malnutrition are massive, pervasive, and often hidden and it stunts growth and erodes child development. At the same time, malnutrition reduces the amount of schooling children attain and increases the likelihood of poverty in adulthood. Notably, the consequences of malnutrition persist through one's life time and across generations such that underweight mothers are more likely to give birth to underweight children. According to the World Bank (2006), malnutrition has big negative consequences on economic performance and evidence shows that it can reduce global gross domestic product (GDP) by up to about USD 2 trillion per year.

On the other hand, as Uganda Bureau of Statistics (UBOS, 2018) states that in Uganda, the prevalence of childhood malnutrition is worse in rural than urban areas like in most developing countries (Ruel et al., 1998). According to UBOS (2018), stunting is highest among rural pre-schoolers (46%) than in urban areas (26%). Despite the low prevalence of stunting in urban areas, overall stunting affects about 225,000 urban pre-schoolers in Uganda. According to the Uganda Demographic Health Survey (UDHS, 2016), stunting stands at 29%, underweight 16%, and wasting 5% for children under 5 years of age. As noted by Martorell (1995), stunting has long-term negative consequences on adult stature, body composition, work capacity, and women's reproductive life.

According to UBoS (2018), agriculture is the back bone of Uganda's economy, whereby it employs about 85% of the labour force and generating about 30% of the country's Gross Domestic Product (GDP). In terms of export earnings, the agriculture sector generates about 90% of export earnings in the country. Also, agriculture is the main source of food to the Ugandan population, however, food security in the country is determined by both supply and demand factors. Land is the key production factor for the agriculture sector. Thus, Uganda's land holding policy (2013) has implications for household agricultural activities. This directly or indirectly affects food production and hence household food consumption in the country. In terms of land ownership, UBoS (2018) states that women own only about 16% of land, and just about 27% of land is registered with formal land titles. The Uganda's land policy (2013) legally recognizes customary, mailo land, freehold, leasehold, and public as forms of land ownership. This has implications on the nature and type of investments one can undertake in the agriculture sector. However, at a deeper level, the purpose of agriculture is not just to grow crops and livestock for food and raw materials, but to grow healthy, well-nourished people.

Although agricultural advances have been impressive in the past decades, Carletto et al. (2015) note that Uganda has not followed suit in improving the nutrition and health status of poor households like in other developing countries. Thus, understanding how diversification of agriculture activities may contribute to improved household welfare and children's nutritional outcomes is gaining ground as an objective among economists and other development professionals (Carletto et al., 2015). In this context, Pingali and Rosegrant (1995) state that diversification of agriculture is most likely to provide a wide range of different types of food to the population in the country. Consequently, the differential effects of diversification of agriculture activities on child nutritional outcomes remain the subject of empirical analysis in Uganda.

The study employs data drawn from World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA), collected by Uganda Bureau of Statistics (UBOS, 2018). For empirical analysis, the study tests whether diversification of agriculture activities has differential effects on children's nutritional outcomes in Uganda. Thus, this article provides answers to the following questions: how does agriculture diversification affect children's nutritional outcomes? How does child nutritional outcomes vary by the gender of the household head? Which socioeconomic characteristics influence child nutritional outcomes? For the purpose of examining the differential effect of diversification of agriculture activities on child nutritional outcomes, the Household Diet Diversity Score (HDDS), Simpson Index (Simpson, 1949), and Shannon Index (Shannon and Weaver, 1948) are calculated. These indices range between 0 and 1 and are used to measure the degree to which households consume a variety of foods.

According to FAO, IFAD, and WFP (2015), worldwide, 795 million people suffer from undernutrition, and out of these, about 780 million people live in developing countries. As FAO (2009) states, incidences of malnutrition and food insecurity are a national burden, which are created by food insecure households. Therefore, such households may remain chronically underfed and unable to fully participate in the economic development of their countries. Also, the ailments arising from poor nutrition is likely to impose pressure on the existing health resources in the country. In fact, according to Carney (1998), diversification of agriculture production not only affects direct access to food and diversity in food intake but also is a source of household income, which households can use to purchase more nutritious foods and enhance children's nutritional status. Thus, households which do not practice agricultural diversification are more likely to suffer from malnutrition and food insecurity. Thus, agriculture production has the potential to boasting household food availability and income, which affect the overall welfare of the household members.

Similarly, Gillespie et al. (2015) state that, not only can practice of diversification of agriculture activities affect household food security and child nutritional outcomes, but also limited information on the wider political, institutional, and policy-related challenges can undermine household's nutritional outcomes. Also, Kadiyala et al. (2014) note that agriculture has the potential to improve child nutrition outcomes, but this potential is yet to be realized in many settings of developing countries. On the other hand, Nankinga et al. (2019) and Mkandawire et al. (2022), note that women's education level and their age can play a distinct role in supplementing children's nutrition outcomes.

In addition, Joshi et al. (2004) indicate that, besides the provision of food to households, diversification of agriculture activities is a means that can be used to increase household income through sell of farm products and alleviate poverty, generate employment throughout the year, conserve soil fertility and water resources. Thus, diversification of agriculture activities can be used as an important strategy to overcome many economic constraints faced by developing countries. Similarly, Eckhardt (2006) shows that poor households who are food insecure usually lack basic micronutrients, with the potential consequence of increasing susceptibility to infection and diseases in the short run, while in the long run likely to suffer from major cognitive impairment. In that essence, Azzari (2014) states that consumption of a variety of different food groups enhances better nutritional outcomes. Similarly, Arimonde et al. (2010) and Mirmira et al. (2006) have documented that consumption of a variety of different food groups leads to nutrient adequacy among women of reproductive age in Burkina Faso, Mali, Mozambique, Bangladesh, and the Philippines.

As Carletto et al. (2015) states, the diversification of agriculture practice has profound effect on the households' dietary patterns and its nutritional status. Thus, Carletto et al. (2015) conclude that households' nutritional status is influenced by a number of factors, such as location, types of commodities produced and consumed, and the role of livestock. Similarly, Ruel and Alderman (2013) and FAO (2011) state that when agricultural interventions are targeted at women and when specific work is done around women's empowerment through behaviour change communication, this can greatly enhance children's nutritional outcome. Also, the authors noted that household members' nutritional status can greatly be improved if change is mediated through women's time use, women's own health and nutrition status, and women's access to and control over resources, as well as intrahousehold decision-making power.

Furthermore, Hoddinnot and Yohannes (2002) noted that households should endeavour to eat both different food varieties and nutritious food in order to realise better child nutritional outcomes. Wamani et al. (2004) have documented evidence that shows that more female children are stunted than their male counterparts in households of poor socioeconomic status than in households of good socioeconomic status. On the other hand, Gillespie et al. (2015) opined that increased food production and/or even consumption does not necessarily mean improved nutritional outcomes. Also, Herforth and Ahmed (2015) indicated that food available, affordable, and convenient, may not necessarily imply that the household is enjoying better nutrition and health outcomes. In essence, Chase and Ngure (2016) submitted that nutrition outcomes of the household is influenced by other factors such as poor sanitation, women's disempowerment, inadequate quality of health services, the absence of nutrition education, and agriculture-associated diseases.

This article starts by providing the introduction which contextualizes the subject under study and sets out the objective of the research, and the empirical evidence from the relevant literature on agriculture diversification and child malnutrition. This is followed by section two which presents the sources of information and the econometric model. Section three presents the result, while the last section presents the main concluding remarks.

MATERIALS AND METHODS

Data

The analysis is based on data drawn from UBOS (2019) Living Standards Measurement Study-Integrated Surveys in Agriculture (LSMS-ISA). The survey collected both quantitative and qualitative data at household-level and it contains information on socioeconomic and community characteristics based on a three-stage stratified random sampling design. The first stage involved choosing the counties from the 15 geographical subregions. This was followed by choosing the enumeration areas in the second stage, while in the third stage, 10 households were randomly selected from each enumeration area. The survey covered 3200 households from both urban and rural areas of the 15 subregions of Uganda. Also, detailed information was collected on agricultural production and marketing, land access and ownership, use of extension services, farming types, size of cultivated and planted land, type, and number of livestock kept, form of employment, household's food and non-food expenditure, number of children under age of five and their anthropometric data, gender of household head, age, education level, family size, and means of access to markets. Also, information on farm production quantity and type of crops or animals, quantity and type of crops purchased, and consumed by the household on a daily or weekly basis. Data was collected twice for the two-season farming seasons. The study focuses only on farming households, who are involvement in agricultural activities through ownership and/or cultivation of land and have non-zero crop production data.

Also, LSMS-ISA collected information on the children's nutrition status that can be used to calculate child stunting, wasting, and underweight (WHO, 2016). In our analysis, we focus on three nutritional indicators: i) stunting which captures height for age. According to Siddiqa et al. (2023), stunting is the result of long-term insufficiencies in food intake; ii) wasting measures weight for height and iii) underweight indicate weight for age. In addition, Siddiqa et al. (2023), note that wasting and underweight measure medium- and short-term nutritional deficiencies. Thus, child underweight manifests itself as a combination of both child stunting and wasting. The study focuses on only the children whose anthropometric information was collected.

Conceptual Framework

This study derives its theoretical foundation from the random utility theory, which states that every individual is a rational decision-maker. Basically, a ration consumer aims at maximizing utility relative to his or her available resource cconstraints. In view of this theory, it can be assumed that given a set of agricultural practices, rational households choose agricultural practice say diversification that maximise their nutritional outcomes for better child health status:

$$E[U(AD)] > E[U(ND)] \quad (1)$$

From Equation 1, U(AD) is the nutritional outcome derived by the household from agriculture diversification and U(ND) is the nutritional outcome from household who do not practice agriculture diversification. Household i decides to practice agriculture diversification if the expected utility from practicing agriculture diversification by rational households is more than for non-rational households not practicing agriculture diversification. Then, we get,

$$U_{ijAD}(\beta_A X_i + \in_i) > U_{ijN}\left(\alpha_{ND} X_i + \in_j\right) \qquad i \neq j \quad (2)$$

Where U_{ijAD} and U_{ijND} are the expected nutritional outcomes by child i (male or female) in rational household j who practice agriculture diversification (AD) and no agriculture diversification (ND), respectively. Then, X_i is a vector of explanatory variables that may influence the choice of agriculture diversification by the rational household that affect children's nutritional outcome; β_{AD} and α_{ND} are parameters to be estimated for the male and female children, while $\in_i$ and $\in_j$ are error terms.

Therefore, a household's decision to choose whether to practice agriculture diversification or not may affect children's nutritional outcomes. Specifically, this study investigates how household's agriculture diversification influences nutritional outcomes among male and female children in Uganda. This implies that the likelihood for household j with X_j characteristics chooses to practice agriculture diversification or not in the probit framework can be specified as:

$$P_i = P_i(Y_i = 1) = \frac{e^{X^{`}}\beta_{AD}}{1+\sum e^{X^{`}}\beta_{AD}} \quad (3)$$

From Equation 3, β_{AD} is a vector of parameters that satisfies ln(P_{iAD}/P_{iND}) = X'β_{AD} a case when a rational household diversifies his/her gricultre activities. Given that the estimated coefficients of the probit are computed relative to the base variable, the direct interpretations of the signs for the estimated coefficients and the magnitudes become difficult. In this case, therefore marginal effects of changes in the explanatory variables are computed on the probability that a rational household practices agriculture diversification (Wooldridge, 2010).

Empirical Strategy

Following the above conceptual framework, it can be observed that the child's nutritional outcome from household j is a function of the household's agriculture diversification practices ($agdiv$) and other socioeconomic and demographic factors, and household characteristics, HX_j. Through diversification, a household grows food for either own consumption or for sell. In the case of own consumption, households that practice diversification are more likely to have a variety of quality food products, which ensures nutrient diversity and quality all year round (Gillespie et al., 2012; Meeker & Haddad, 2013; Ruel et al., 2013). On the other hands, diversification for market purpose increases household incomes through sales of a variety of products, while at the same time increases households' purchasing power of more nutritious foods in the market (Webb, 2013; World Bank, 2013; Herforth and Harris, 2014; Jones et al., 2014; Kadiyala et al., 2014). Thus, diversification of agriculture activities is important in ensuring better household welfare as it increases households' ability to access better quality food and in diversity. Also, FAO (2015) states that diversification of agriculture actives enables households to absorb climate and price shocks, that may cause seasonal food reduction and income fluctuations.

The proposed empirical panel probit model for analysing the effect of households' agriculture diversification practice on a children's nutritional outcome can thus be written as:

$$Childn_{ijt} = \alpha_i + \beta agdiv_{ij} + \gamma X_{ij} + \delta HX_{ij} + \emptyset HDDS_{ijt} + \theta CC_{ijt} + Z_t + u_{ij} \quad (4)$$

The standard econometric model (Equation 4) links the nutritional outcomes ($Childn_{ijt}$) of child i (male or female) in an urban or rural area with household agriculture diversification practices. Where, $Childn_{ijt}$ is a dependent variable that measure prevalence of stunting, underweight and wasting of children i from household j at time t. The agriculture diversification ($agdiv$) of household j, the socioeconomic and demographic factors of the household head such as age, gender, race, religion, marital status employment status, drunkard ness, smokes etc. In addition, this variables capturing household characteristics (rural/urban, ownership of the home, neighbourhood, household head, household size etc). Additionally, we employ CC as a vector of unique child's features (child's gender), and Z_t is time variant measure.

The dependent variable is binary and is coded as "1" if a child is malnourished say the child is stunted or underweight or wasted and "0" if child not malnourished. As WHO (2006) states, children whose Z-scores are below -2 SD is regarded as stunted or underweight or wasted and those children whose Z-scores value is above -2 SD. These three standard anthropometric indicators most used for monitoring malnutrition (WHO, 2006).

The Household Diet Diversity Score (HDDS) [1] is calculated by aggregating foods consumed by the child in the surveyed household. This include the food groups consumed by the household in the seven days prior to the interview. In calculating the HDDS, the consumed food items are grouped into equally 12 weighted groups which include Cereals (A), Roots and tubers (B), Vegetables (C), Fruits (D), Meat poultry, and offal (E), Eggs (F), Fish and seafood (G), Pulses, legumes, and nuts (H), Milk and milk products (I), Oil/fats (J), Sugar/honey (K), and Miscellaneous (L). Following Swindale and Blinsky (2006) and Kennedy et al. (2013), the HDDS is calculated by summing these food groups and each food group is a ssigned a score of 1 if it is consumed by the household and score of 0 otherwise. Thus, the overall HDDS ranges between 0 and 12 for our empirical analysis.

According to Arimond and Ruel (2004), HDDS is an important indicator of the available food groups in a household's meals. However, it does not capture variations in the distribution of consumption since all groups are similarly weighted regardless of quantity ingested. In order to take into account households' food diversity, the Simpson Index (Simpson, 1949) and the Shannon Index (Shannon and Weaver, 1948). Here a variant of food groups such as starchy foods, legumes, nuts, seeds, starchy vegetables, non-starchy vegetables, starchy fruits, non-starchy fruits, dairy, and eggs are included. The index provides the relative level of foodconsumption concentration by the households and its welfare effect. The Simpson and Shannon indices are more

[1] The foods that are used to calculate HDDS include own grown food and purchased foods, and foods received as gifts for consumption. Thus, HDDS is used as a continuous variable.

frequently employed to shed light on the consumption diversity of the household regarding the food items consumed for a balanced diety.

Model 4 is estimated using an instrumental variable approach to control for possible omitted variable bias and endogeneity. As Wooldridge (2010) and Bollen (1989) state, the problem of omitted-variable bias occurs when a relevant independent variable is omitted in the model. This omission affects both the dependent variable and correlation with error terms violates the exogeneity assumption of the ordinary least squares (OLS), and manifests into endogeneity problem. In addition, the simultaneity problem arises when one of the model predictors is jointly determined along with the dependent variable (Wooldridge, 2010). Wooldridge (2010) notes that measurement errors cause endogeneity problem when measurement errors in the model ppredictor variable leads to attenuation bias. Thus, in the case of standard regressions, presence of endogeneity renders coefficient estimates to be inconsistent and unbiased resulting into spurious regression results. Three sources sources of endogeneity have been documents including omitted variables bias, simultaneity, and measurement errors (Wooldridge, 2010). Following Bai et al. (2019) and Dang and La (2019), the endogeneity problem is addressed by taking 'average number of households' meal at household level, other than the household in the country' as an instrument for the household's number of meals. In this case, household level instrumental variable is used to eliminate any biases due to reverse causality at the household level (Dang and La, 2019), who used panel data and analysed data using stata.

RESULTS and DISCUSSION

Descriptive Results

Figure 1 presents the chilld malnutrition prevalence in Uganda. The data shows that nation wide children suffer from stunting ranging as high as 33% in 2009, reaching 34% in 2012 and falling to 31% in 2013 and 25% in 2015. To note, stunting was highest in 2012, and this reduced by 9% as per 2015. Notably, children wasting is less prevalent among Ugandan Children.

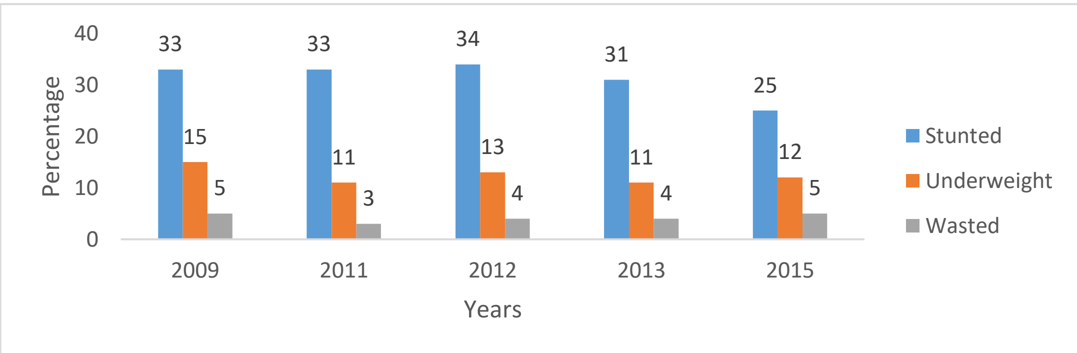

Figure 1. Child Malnutrition Prevalence in Uganda (%), (Source: UNPS (UBoS, 2009, 2010, 2011, 2013, 2016)

Figure 2 presentss child malnutrition prevalence by regions. It can be observed that the Western region had a highest prevalence rate of stunted children (41%) in 2011, followed by the Eastern region (37%), the Northern (32%), while the Central had the lowest prevalence rate (30%). On the other hand, the Northern region had the highest prevaence of underweight children (17%) in 2009, followed by the Eastern region (15%) in 2012 and 2015, while the Central region had the lowest prevalence of underweight children (7%) in 2015. Figure 2 shows that child wasting is less prevalent and it ranges between 2% and 6% over the study period in the different regions.

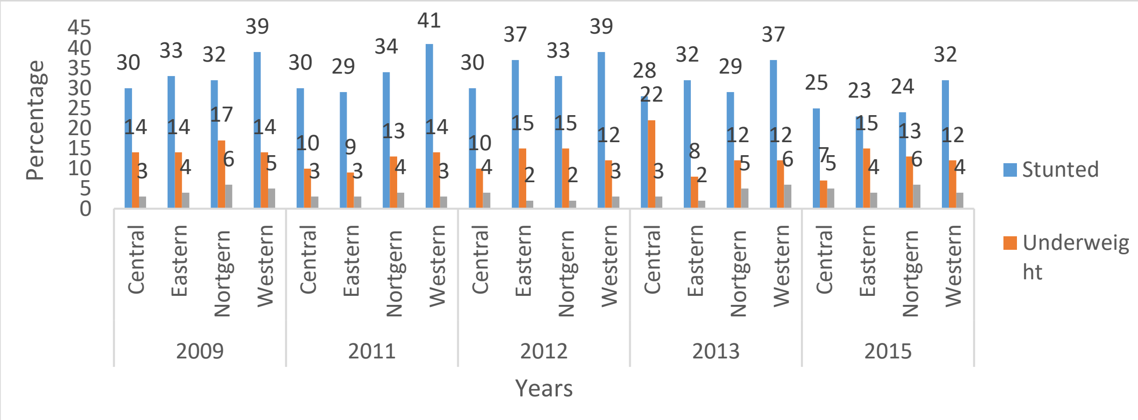

Figure 2. Child Malnutrition Prevalence by Region in Uganda (%), Source: UNPS (UBoS, 2009, 2010, 2011, 2013, 2016)

Figure 3 presents child malnutrition for rural and urban areas in Uganda. The data child malnutrition is more prevalent in rural areas with 37%) of children suffering from stunting in 2009. In urban areas, child stunting was 22% of under five children in 2012 and 2013. Figure 3 shows that prevalence of underweight among children stood at 16% among rural children in 2009, while in urban areas it was 10% in 2011. In addition, prevalence of child wasting among children in urban areas at 7% in 2015, whiile child wasting in rural areas was 5% in 2009.

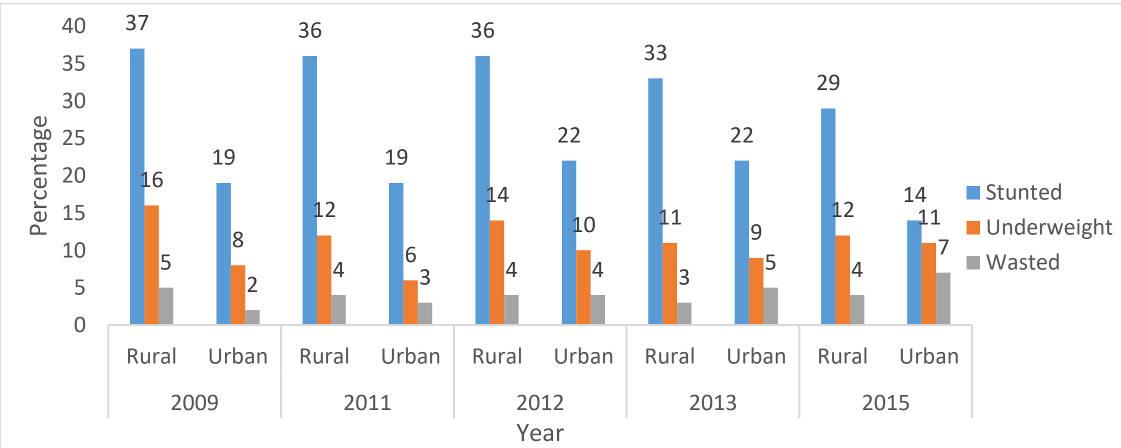

Figure 3. Child Malnutrition Prevalence by Residence in Uganda (%), Source: UNPS (UBoS, 2009, 2010, 2011, 2013, 2016)

Figure 4 shows that prevalence of child stunting is low among female headed households compared to male headed households for the study period. On the other hand, pprevalence of underweight, and wasting were lowest among children in female headed households at 9% and 4% respectively. The data indicates that women are more likely to give child nutrition more importance than their male counterparts by providing more balanced diety to the children.

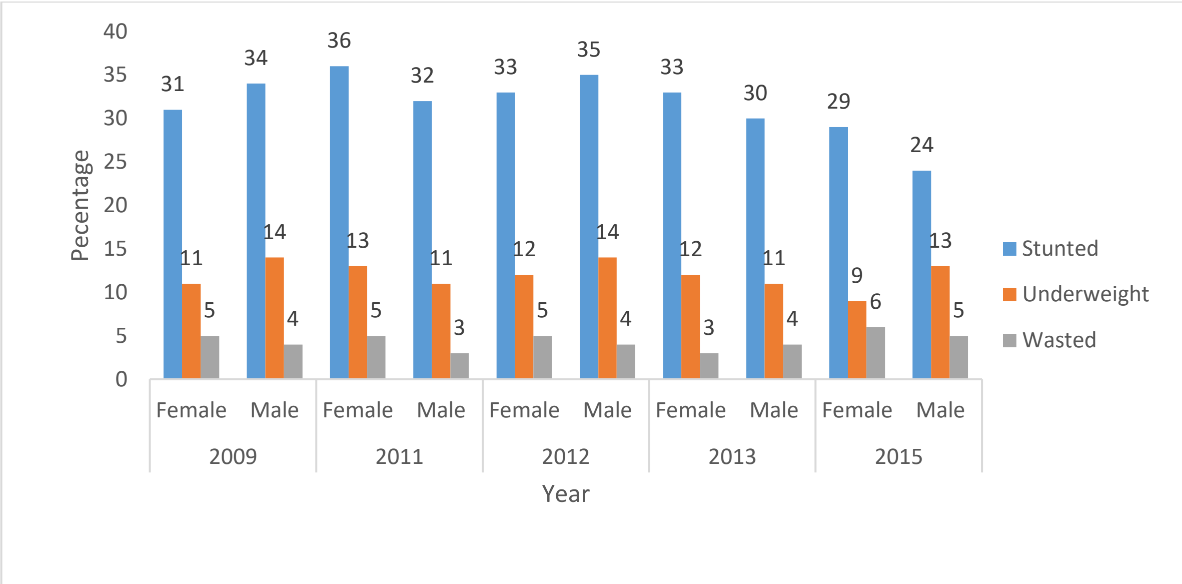

Figure 4. Child Malnutrition Prevalence by Sex of Household head (%), Source: UNPS (UBoS, 2009, 2010, 2011, 2013, 2016)

Empirical Findings

Table 1 presents determinants of the differential effects of diversification of agriculture activivities on child nutritional outcomes (stunting, underweight and wasting) in Uganda. For robust estimated results, three Instrument probit panel models for the child nutritional outcomes are estimated (Table 1). Overall, the Wald test is significant for all the IV models estimated. This means that we can reject the null of no exogeneity at 5% level. In addition, the Smith-Blundell test result of exogeneity results are rejected. The rejection of the exogeneity results implies that the standard probit estimator would yield incosistent and biased reasults, thus, the differential effect of diversification of agriculture activities on child nutritional outcomes should be estimated using an IV-probit technique. Overall, the Wald test results indicates that the estimated IV models exhibit a good fit for the set of selected covariates and the variables have expected signs.

Table 1 presents the estimated marginal effects of the differential effects of diversification of agricultural activities on child nutritional outcome in Uganda. Three model specifications are estimated.

Table 1. Effects of agriculture diversification on child nutrition outcomes in Uganda

Variables	Stunted Model 1 ME	 Model 2 ME	Underweight Model 3 ME	 Model 4 ME	Wasted Model 5 ME	 Model 6 ME
Agriculture diversification	-0.054***		-0.031**		0.057	
	(0.001)	(0.063)	(0.044)	(0.001)	(0.567)	(0.094)
HDDS		-0.010*		-0.008*		-0.001
		(0.068)		(0.068)		(0.736)
Planted area	-0.033***	-0.077***	-0.044*	-0.056***	-0.004	-0.013*
	(0.002)	(0.001)	(0.069)	(0.000)	(0.462)	(0.055)
Total land ownership	-0.237***	0.040**	-0.095*	-0.060	-0.052**	0.003
	(0.000)	(0.032)	(0.079)	(0.105)	(0.034)	(0.156)
Household size	0.068**	0.033***	0.001	0.007	0.001	0.001
	(0.041)	(0.000)	(0.730)	(0.976)	(0.493)	(0.451)
Male HH-head	0.057**	0.065***	0.006	0.005	-0.000	-0.001
	(0.020)	(0.009)	(0.775)	(0.837)	(0.971)	(0.949)
Mother's age (years)	-0.009**	-0.021*	0.007**	-0.019***	-0.006*	0.012**
	(0.029)	(0.069)	(0.042)	(0.009)	(0.069)	(0.033)
Mother's age squared (years)	0.007*	0.037***	0.006*	0.035*	0.027***	0.013*
	(0.088)	(0.000)	(0.062)	(0.057)	(0.000)	(0.042)
Education (RC: No education)						
Primary	0.033*	0.007***	-0.031	0.018	0.016**	-0.011
	(0.087)	(0.000)	(0.107)	(0.335)	(0.014)	(0.168)
Secondary	-0.017*	-0.018	-0.010	-0.012	-0.009	-0.011
	(0.081)	(0.384)	(0.553)	(0.467)	(0.324)	(0.225)
Postsecondary	-0.091***	-0.095**	-0.075***	-0.072*	-0.015*	-0.029***
	(0.000)	(0.021)	(0.000)	(0.055)	(0.061)	(0.001)
Male child	0.059***	0.064***	0.005	0.008	0.002	0.002
	(0.000)	(0.000)	(0.680)	(0.523)	(0.766)	(0.836)
Urban household dummy	-0.093***	-0.086**	-0.030*	-0.031*	-0.002	-0.000
	(0.000)	(0.041)	(0.081)	(0.086)	(0.858)	(0.995)
Presence of produce market	-0.061***	-0.031	-0.020**	-0.041	-0.072	-0.020
	(0.000)	(0.151)	(0.014)	(0.554)	(0.432)	(0.743)
Regions (RC: Freehold)						
Customary tenure	-0.013	-0.012	-0.024	-0.019	-0.012	-0.013
	(0.589)	(0.597)	(0.183)	(0.300)	(0.260)	(0.226)
Leasehold,	-0.049**	-0.050**	-0.014	-0.011	0.008	0.006
	(0.031)	(0.027)	(0.456)	(0.577)	(0.533)	(0.644)
Mailo	0.081***	0.085***	-0.012	-0.009	0.012	0.009
	(0.003)	(0.002)	(0.532)	(0.656)	(0.391)	(0.512)
Marital status (RC: Single)						
Monogamously	0.079	0.061	-0.022**	-0.041	-0.009	-0.011
	(0.230)	(0.379)	(0.044)	(0.560)	(0.832)	(0.805)
Polygamous	0.095*	0.179	-0.029	-0.042	-0.023	-0.024
	(0.077)	(0.103)	(0.608)	(0.424)	(0.328)	(0.287)
Divorced/separated	0.155	0.151	-0.023	-0.039	-0.013	-0.014
	(0.139)	(0.151)	(0.690)	(0.459)	(0.689)	(0.662)
Household expenditure	0.100***	0.083***	0.038**	0.021	0.010	0.009
	(0.000)	(0.000)	(0.027)	(0.257)	(0.350)	(0.425)
Observations	2,459	2,424	2,470	2,433	2,448	2,412
Log likelihood	101.5	12.78	41.21	97.13	14.12	32.27
F test (instrument)	1,510	1,211	1,221	1,100	1,798	1,122
LR test/ Wald test of	1876.15	0.920	928.39	0.990	929.16	13.200
exogeneity	(0.000)	(0.337)	(0.000)	(0.320)	(0.000)	(0.000)
Wald χ 2	209.3	208.7	42.50	30.13	16.92	16.46
Prob > F/ χ 2	(0.000)	(0.000)	(0.002)	(0.068)	(0.003)	(0.088)

p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

The estimated marrginal effect on the diversification measures is negative and statistically significant. This means that diversfication of agriculture activities is very important in influencing child nutrition status in Uganda. The results show that diversification practice significantly reduces child stunting in households that practice diversification by between 5% and 3%, wasting by 3%, and underweight by between 1% and 3%, compared to children living in households that do not practice diversification.

This finding is in line with findings by Carletto et al. (2015) and Joshi et al. (2004), who also found that diversification of agriculture activities is vital to households in terms of food security and the nutrition requirements of their children. Also, diversification of agriculture activities has the potential to increases households' income, employment and poverty alleviation among others. These results suggest that agriculture diversification practices are a critical resource that has profound effect on housheolds' food security and nutritional status of children, especially for the agriculture based economies like Uganda, where 80% of the population derives their livelihood from agriculture (Carletto et al., 2015; UBoS, 2016).

The estimatedd marginal effects (Table 1) show that HDDS has a negactive and significant effect of child malnutrion status. This findings means that children living in households that consume high food diversity with better quality are likely to be less stunted and underweight compared to children living in households with low food diversity. This may provide an explanation for the need to have better food variety and food security, which have both a direct and indirect effect on the child nutrition outcomes. These findings confirm the findings obtained by Onyango et al. (1998) and Azzari (2014) who found that improved consumption of nutritious foods, i.e., high HDDS, improves child nutritional outcomes by reducing child stunting and underweight.

In addition, the marginal effects in Table 1 shows that planted land area has a significant reducing effect on the likelihood of child stunting by 3.3% and 7.7%, underweight by 4.4% and 5.6%, and wasting by 1.3%. This is results means that an increase in the proportion of planted area by the household increases agriculture output, which ensures the availability of nutritious foods for households. Hence, increased planted acreage can only be beneficial for nutrition if the resulting food production or income is used to purchase more nutrient-rich foods. Also, the estimated marginal effects on total acreage effects reveals that a unit increase in total acreage reduces the prevalence of child stunting by between 2.4 and 4%, underweight by 9.5%, and wasting by 5%, other factors being constant. These findings confirm the findings obtained by Ruel and Alderman (2013), who note that increased planted area enhances food production and provides high-nutritional food to households, thereby improving children's nutritional outcomes.

Household size remains a key contributor to nutrient intake, perhaps underscoring the common dependency on family labour among smallholder farmers as results in Table 1 show. It is thus possible that since smallholder farmers practice agriculture to meet their consumption needs, nutritional considerations are borne in mind in making their choice of what is produced. Furthermore, the marginal effect in Table 1 has a positive and significant effect on child nutritional outcomes. This means that children in overly large households are likely to miss food or be underfed as they compete for food among the large household members, and this might deny young children sufficient food consumption that may subsequently cause poor child nutrition outcomes. The estimated marginal effects means that one additional member to the household is likely to increase prevalence of child stunting by between 7% and 3%, while the prevalence of wasting is likely to increase by 3%, with other factors remaining constant. These findings confirm the findings obtained by Herforth and Ahmed (2015), who reiterated the importance of household size on children's nutritional outcomes. The bigger the household size, the small the food rations among the household members and the more likelihood of having malnourished children.

Also, the estimated marginal effects in Table 1 show that gender of the household head is important in influencing the nutritional status of the children. The findings in Table 1 indicate that children living in female-headed households reduces prevalence of child stunting is reduced by 3% and wasting by 1% compared to children living in male-headed households. This finding in Table 1 indicates that female household heads are more concerned with children feeding than their male counterparts. This finding confirms the findings by Farid and Wadood (2010), who found that mothers/women usually take more care of children than their male counterparts. Also, this findings confirm the findings by Smale et al. (2015), who found that there is a strong positive association between female gender and children's diet.

Interestingly, marginal effects on mother's age as a proxy for the productive and parenting behaviour of women, show that one additional year in the age of the young mothers (linear effect) increases prevalence of child wasting by 2% and underweight by 2%, other factors being constant. On the other hand, after a certain age, the marginal effects estimates on age squared (nonlinear effect of age) show that one additional year in the age of an old mother reduces the prevalence of child stunting, wasting, and underweight by 3%, 4%, and 1%, respectively, other factors being constant. Our findings confirm the findings by Nankinga et al. (2019), who noted that a mother's reproductive age is important for overall child early health outcomes. These findings mean that old mothers have the experience of taking care of children's feeding more than the young mothers. These results show that is a need to promote advocacy for delayed motherhood to promote better child nutritional outcomes in Uganda.

Furthermore, the estimated marginal effect on education of household heads show that education of household heads has an influencing effect on childhood nutritional outcome in Uganda. Overall, children living in households headed by heads with primary education reduces prevalence of childhood stunting among children by between 0.7% and 3.3% compared with counterparts tliving in households headed by heads with no education, while the prevalence of childhood wasting reduces by approximately 1.6%, other factors held constant. The results indicate that other factors held constant having secondary education reduces prevalence of childhood stunting by 51.7% in reference to counterparts with no education. Also, household heads with postsecondary education reduces prevalence of childhood stunting by between 9.1% and 9.5%, underweight by 7.5% and 7.2%, and wasting by between 1.5% and 2.9% compared to counterparts with no education. These findings confirm the findings obtained by Herforth and Ahmed (2015), who found that education is critical to children's growth and early development.

In addition, the estimated marginal effects show that the gender of the child has a significant effect on child nutrition outcomes. The results in Table 1 indicates that being a male child increases prevalence of childhood stunting by 6% compared to their female counterparts, other factors remained constant. As expected, living in an urban area reduces the prevalence of child stunting by 9% and underweight by 3% compared to children living in rural areas, other factors remained constant. This finding confirms the findings obtained by Wamani et al. (2004), who found that urban residents have more accessibility to nutritious food as all farmers produce and sell to urban dwellers. Also, the results reveal that the accessibility to a product market by households reduces the prevalence of childhood stunting by 6% and underweight by 2% compared to households with no access to product markets. This finding confirms the findings obtained by Gillespie et al. (2015), who noted that the presence of a product market increases the availability of nutritious food among households, which significantly affects childhood malnutritional outcomes. Also, on an all-other-things equal basis, Table 1 shows that the land tenure system has a significant effect on the prevalence of childhood malnutrition. That is, children living in households with mailo land ownership reduces the prevalence of childhood stunting between 8.1% and 8.5% compared to its counterparts with freehold land ownership. This finding confirms the findings obtained by Gillespie et al. (2015), when they reiterated that land is a critical asset for the availability of nutritious food among households.

As expected, other factors held constant; marital status of household head significantly influences childhood nutritional outcomes in Uganda. Results show that households that are monogamously married reduce the likelihood of childhood stunting by 4% compared to the base category of households that are single. Also, other factors held constant, polygamously married household heads increase the likelihood of child stunting by 10% compared to children with single parents. Finally, other factors held constant, household food expenditures reduced the likelihood of childhood stunting by 10% and underweight by 4%. This finding confirms the findings obtained by Ellis (2000), which noted that the higher the household food expenditure, the better the childhood health outcomes.

CONCLUSION and RECOMMENDATIONS

This article examines the differential effect of diversification of agriculture activities on child nutrition outcomes in Uganda using data drawn from the Uganda National Panel Survey. The study employed Instrumental panel probit focusing on diversification of agriculture activities socioeconomic and demographic characteristics of the household. The key study findings reveal that female household head, high education level, household size, size of planted crop area, access to product markets, household food expenditure, and mailo land ownership significantly influence the prevalence of childhood stunting, underweight, and wasting among children. On the other hand, low education levels of household heads, male children, living in rural areas, and polygamously married household heads significantly increase the probability of child stunting, underweight, and wasting.

The findings have a number of policy implications. First, efforts need to be put in place for households' access to agricultural land is one of the critical entitlements that is likely to pave the way for children's access to food, diversity in food, and socioeconomic and nutritional security. Second, there is need for government to design gender based policy targeting women in vulnerable communities where there is scope for change from male-dominated productive assets such as land ownership to minimize food shortages. Third, our results show that giving women ownership of farmland is beneficial not only in terms of improving gender equality but also due to the important positive effects this has on a household's food security. Therefore, government should ensure that the land titling and registration programs prioritize assigning land titles jointly to both spouses or partners and ensure that the woman receives legal recognition of tenure for her plots where applicable. In addition, deliberate measures should be undertaken by policymakers in an effort to modify the inheritance laws that can provide women with equal rights to land inheritance as men. This is likely to have significant effect on food agriculture production and consequently food security and nutrition outcome of children. In addition, government should undertake measures aimed at strengthening gender-sensitive approaches to boast agricultural production that do not set men and women in opposition to one another. Specifically, there is need to increase women's control over land, physical assets, and financial assets as a mean to boast agriculture productivity and hence better child health and nutrition outcomes.

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Conflict of Interest Statement

We hereby declare that that there are no competing interests.

Authors Contribution

FB was responsible for contextualisation of the study. FB conceived and designed the study, analysed the data, and final editing of the paper. TJ was responsible for literature review, and manuscript preparation and overall edits of the manuscript.

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