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Nutrition Outcomes of Under-five Children of Smallholder Farm Households: Do Higher Commercialization Levels Lead to Better Nutritional Status?

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Abstract

The study investigated the nutritional status of under-five children of farm households. The study utilized primary data from 352 farm households with 140 under-five children. Household crop commercialization index (CCI) was used to estimate cassava farm household crop sale ratio and categorize the households into four commercialization levels while WHO Anthro software was employed to analyze under-five children anthropometric indices such as weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ). Logit regression model (LRM) was used to examine the drivers of under-five children's nutritional status of farm households. The study found that 42.9%, 7.9% and 3.6% of the children are stunted, underweight and wasted respectively. The highest stunting level was recorded in zero level households (CCI 1). Although, some higher CCI households (medium-high and very-high level) recorded increased percent of stunted children. This revealed that being a member of low or high-level commercialization households may not guarantee better nutritional status of young children of farm households. The results of LRM indicated that the predictors of children nutritional status were child's age, farm size, access to electricity, healthcare and commercialization variables. Moreover, weak positive and negative relationships exist between CCI and children's nutrition outcomes as measured by the z-scores. The study recommended maternal nutrition-sensitive education intervention that can improve nutrition knowledge of mothers and provision of infrastructure that enhance increased farm production and promote healthy living among farm households.

Keywords Farm households · Crop commercialization index (CCI) · Malnutrition · Stunting · Under-five children · WHO Anthro

Extended author information available on the last page of the article

1 Introduction

The number of hungry people have increased globally from 653.2million (8.7%) in 2017 to 687.8million (8.9%) in 2019. Meanwhile, the prevalence of undernourishment remained relatively unchanged since 2015, but moved up from 8.0% to 2019 to about 9.3% in 2020 and the increase continued in 2021 reaching 9.8% (FAO et al.,). While it is quite alarming that the number has continued to rise in Africa since 2015 and reached 250.3million (19.1%) in 2019 and this was projected by Food and Agriculture Organization (FAO) to reach 433.2million (25.7%) by 2030 (FAO et al., 2020). It is quite alarming that Africa bears the most devastating burden of hunger where 20.2% (278million) of the population (1 in 5 persons) was affected by hunger in 2021 (FAO et al., 2022). In recent time, malnutrition has remained a global phenomenon impeding developmental agendas with unsatisfactory human reverberations (Global Nutrition Report, 2018, 2020; Otekunrin et al., 2021a). The health and well-being of young children and adolescents are of paramount importance to every country as they are regarded as one of the crucial drivers of future economic and societal development (WHO, , Otekunrin & Otekunrin 2022). However, in 2019, under-five children malnutrition surged with 21.3% (144.0million) stunted, 6.9% (47.0million) wasted and 5.6% (38.3million) overweight. Meanwhile, empirical evidence revealed that 20million babies are born with low birth weight annually while overweight and obesity adults are at critical level of about 40% (Global Nutrition Report, 2018, 2020; UNICEF et al. 2020; Otekunrin & Otekunrin 2021a). Meanwhile, in 2020, the number of under-five children that are stunted climbed to 149.2million, 45.4million are wasted while 38.9million are overweight (Global Nutrition Report, 2021; UNICEF et al.,).

In Nigeria, according to National Nutrition and Health Survey 2018, children percentage stunting, wasting and underweight stood at 32.0, 7.0 and 19.9 respectively (National Nutrition and Health Survey, 2018). However, the proportion of undernourished population in Nigeria increased from 9.3% to 2000 to 14.3% in 2018 (Grebmer et al., 2019; Otekunrin et al., 2020a; Ayinde et al., 2020; Otekunrin, 2021a).

However, increasing incidence of food insecurity and hunger especially in Sub-Saharan Africa (SSA) is related to the rising unaffordability of high-quality diets and prevalence of malnutrition (Otekunrin et al., 2019a; FAO et al., ; FAO et al.,2022; Otekunrin & Otekunrin 2022) Also, the emergence of COVID-19 has heightened hunger and food insecurity in all parts of the world (Otekunrin & Otekunrin, 2021a; FAO et al., ; Otekunrin et al., 2021a). According to FAO et al. (2022) recent estimates, hunger affected 46million more people globally in 2021 compared to 2020 and a total of 150million more people since 2019 before the emergence of COVID-19 pandemic. The report projected about 670million people still be undernourished in 2030 (FAO et al., 2022). With 282million malnourished population (1/3 of global population) found in Africa in 2020 and 25million more people were unable to afford healthy diets in 2020, revealing that malnutrition remained a serious challenge in the region (FAO et al., ; Otekunrin et al., 2020a, b; FAO et al., 2022).

However, a study revealed that many of the malnourished population are high among smallholder farm households in poor nations who depend mostly on agriculture as main of livelihood (IFPRI, 2017; Otekunrin et al., 2022a; Otekunrin &

Otekunrin, 2022). Good health of members of farm households, mostly young children and adolescent members (future head of households) are crucial to their agricultural productivity, produce marketing and that of the nation's food security strategy.

Agricultural commercialization is regarded as when agricultural operations depend mainly on the market for the sale of produce and for the purchase of production inputs (APRA,). More so, agricultural commercialization refers to increased market transactions in a position of enjoying the gains from specialization (Carletto et al., 2017; Opondo et al., 2017; Otekunrin et al., 2019b, 2022a). The estimation of the extent of commercialization of smallholder agriculture from the output side of production offers us the opportunity to take advantage of marketing behaviour from (real small-scale to full commercialization) of individual households (Carletto et al., 2017; Opondo et al., 2017; Otekunrin et al., 2019a, 2022b; Otekunrin,2022).

In SSA, previous studies argued that smallholder farmers accounted for most of the people and they partake actively in agricultural production. Furthermore, about 75% of SSA's land are being utilized by them (Martey et al., 2012; Lowder et al., 2016; Otekunrin et al., 2019b; Ayinde et al., 2020). Due to the importance of the smallholder farmers in transformation process of nation's agricultural sector mostly the developing economies, effort is geared towards revitalizing the sector through entrepreneurial drives such as commercialization. This was a welcome idea among smallholder farmers and a step towards reorienting them on subsistence agriculture (Braun, 1995; Barrett, 2007; Wright, 2009; Jaleta et al., 2009).

However, previous studies reported less diverse diets, poor healthcare access, unimproved toilet facilities, and epileptic power supply (and near zero access to electricity) as part of the factors influencing the prevalence of malnutrition (poor nutritional status) among young children in Nigeria and most Sub-Saharan African countries (UNICEF, 2021; Omotayo et al., 2021; Adeyonu et al., 2022a; Otekunrin & Otekunrin,; Otekunrin et al., 2022a; Otekunrin,2021a).

Furthermore, studies from Greece also opined the importance of these factors such as; access to improved toilet and access to electricity in understanding and measuring child well-being in Attica, Greece (Leriou, 2019; Leriou et al., 2021; 2022).

However, previous works argued that children in highly commercialized households recorded a higher incidence of stunting and underweight and likewise level of market participation among smallholder farmers in developing countries also found negative correlation between children nutritional outcomes and commercialization (Okezie & Nwosu, 2007; Carletto et al., 2017). Also, recent study on malnutrition status of under-five children of farm households in Nigeria was determined through the use of Mid Upper Arm Circumference (MUAC) and found 44% prevalence of malnutrition among girls (Adeyonu et al., 2022b). However, this study is the first that focuses on the influence of CCI levels on nutrition outcomes of under 5-year children among rural farm households using primary survey data and employing WHO Anthro software to analyze nutrition outcomes.

2 Methods and Materials

2.1 Study Area

The study was carried out in Ogun and Oyo states (South-West) of Nigeria. However, Nigeria is located in West Africa within the land mass of 923,768 square kilometer with latitude 10° 00^{l} N and 8° and 00^{l} E (Maps of World, 2021). It is a multi-ethnic nation where Igbo, Hausa and Yoruba are regarded as the most common ethnic groups. South-West is one of the six geo-political zones in Nigeria. There are 6 states in South-West. Agriculture is regarded as the major occupation of about 70% of the rural population (Lawal & Samuel, 2010; Otekunrin et al., 2021b).

2.2 Sampling and Data Collection Procedure

This study utilized primary data which was collected through multi-stage sampling procedure. Firstly, two (2) from six (6) cassava producing States in the Southwestern Nigeria was randomly selected. Secondly, the selection of five (5) Local Government area (LGAs) from Oyo State and three LGAs from Ogun state giving a total of eight (8) LGAs in the two states. In stage 3, 24 villages from the 8 LGAs was selected while the fourth stage included the selection of 16 cassava farming households resulting in 384 farm households. The data were gathered using structured questionnaire which include; the household socioeconomic factors, nutrition, child-centred factors, expenditure on food and other salient household and child-centred issues. Thirty-two of the questionnaires were unusable after data cleaning. In the 352 farm households, there were 140 under 5-year members. However, anthropometric measurements such as age of child, gender, height and weight were measured and recorded. These measurement details were used in obtaining malnutrition indices such WAZ, HAZ and WHZ.

2.3 Data Analysis

2.3.1 Evaluating the Levels of Agricultural Commercialization

The CCI levels of cassava farm households in the study areas were estimated, while making use of Crop Commercialization Index (CCI) by Strasberg et al., 1999; Carletto et al., 2017 and Otekunrin et al., 2019b; Otekunrin et al., 2022a, b which is expressed as:

$$CCI_i = \frac{Grossvalueofcropsale_{hhi,yearj}}{Grossvalueofallcropproduction_{hhi,yearj}} \times 100 \quad (1)$$

We have hh_i as the $_i{}^{th}$ household in year *j*.

Using this method, agricultural commercialization can be expressed as a continuum spanning complete subsistence ($CCI_i = 0$) to full commercialization ($CCI_i = 100$). Using this this method, cassava farm households were grouped on the basis of their cassava commercialization levels. From non-participant farm household which

are grouped as (i) zero commercialization households (CCI = 0%) to participating households which are classified into; (ii) low commercialization (CCI=1–49%) (iii) medium-high commercialization (CCI = 50–75%) and (iv) very-high commercialization (CCI = > 75%) levels (Otekunrin, 2021b; Otekunrin & Otekunrin, 2021b).

2.3.2 Anthropometric Measurements of Under-Five Children

Anthropometry is a human body measurements that are mainly used to obtain important nutrition details concerning a sample or population (Babatunde et al., 2011). Past farm household studies have applied anthropometric data to under 5-year children in Nigeria (Babatunde et al., 2011; Ogunnaike et al., 2020; Adeyonu et al., 2022; Ashagidigbi et al., 2022). The anthropometric measurements are used in obtaining indices such as HAZ, WAZ and WHZ (Babatunde et al., 2011; Slavchevska, 2015; Fadare et al., 2019; Bhargava et al., 2020; Otekunrin,2021b). Empirical studies on anthropometric measurements (using WHO Anthro software) of under 5-year members of rural farm households are scarce. The anthropometric measurements for under-five were measured using stunting (HAZ), wasting (WHZ) and underweight (WAZ). The anthropometric indices of under-five members of cassava farm households were obtained for this study using WHO Anthro software. These are stunting, wasting and underweight. However, children (> 5years) having HAZ < -2 Standard Deviation (SD) and < -3SD compared to 2007 WHO reference were classified as stunted and severe stunting, WAZ < -2SD and < -3SD referred to as underweight and severe underweight while WHZ < -2SD and < -3SD referred to as wasting and severe wasting respectively (WHO, 1995, 1997; de Onis et al., 2007; Babatunde et al., 2011; Slavchevska, 2015; Bhargava et al., 2020).

2.3.3 Modelling the Drivers of Under-Five Malnutrition

The drivers of under 5-year children's malnutrition (stunting, wasting and underweight) of farm households were analyzed using LRM as expressed in Eq.(2) below. However, the regressand (dependent variables) are the malnutrition status of the children members of the farm households and are presented in separate regression models. In each case, one (1) is for malnourished child and zero (0) otherwise (i.e. stunted = 1, 0 otherwise; wasted = 1, 0 otherwise; and underweight = 1 and 0 otherwise) as expressed as a function of a vector of explanatory variables assumed to affect the malnutrition of farm under 5-year children. This indicated that in each case, the parameter estimate indicates the likelihood that a child will be malnourished. However, the positive sign on the parameters shows high-level of malnutrition while the negative sign reveals low-level of malnutrition (Babatunde et al., 2011). The explanatory variables included in the model are; child age, child gender, age of mother, education level of mothers, household size, farm size, household head educational level, farm income, non-farm income, food expenditure, mothers' access to nutrition training, healthcare access, toilet access, access to electricity, piped water access and crop sold ratio.

Following Gujarati & Porter 2009 and Otekunrin et al., 2022a, b, the logit regression model is expressed as:

Table 1 Description of household and child-related factors

Variables	Description	Mean ± SD
Child's age	Age of child (months)	32.8 ± 17.5
Size of household	Persons in the household	5.8 ± 2.3
Age of HH	Household head's age (years)	49.6 ± 10.9
Mother's age	Age of child's mother (years)	39.5 ± 9.6
Education of HH	Years of schooling of household head	7.0 ± 4.0
Education of moher	Years of schooling of child's mother	4.9 ± 3.8
Mother's BMI	Mother of child's body mass index (Kg/m^2)	24.1 ± 14.3
Farm size	Household cassava farmland (hectare)	1.4 ± 1.0
Farm income	Annual household farm income (Naira)	139,250 ± 120,669
Nonfarm income	Household nonfarm income (Naira)	66,250 ± 64,641
Expenditure on food	Household food expenditure (monthly)	21,892 ± 8,824
		86.9 ± 14.2
Under-five Ht	Under-five height (Cm)	13.4 ± 3.6
Under-five Wt	Under-five weight (Kg)	-1.59 ± 2.20
Under-five HAZ	Under-five HAZ	-0.21 ± 1.33
Under-five WAZ	Under-five WAZ	1.04 ± 1.71
Under-five WHZ	Under-five WHZ	

Source: Underlying survey data, 2020. Note: Exchange rate (ER) in 2019–2020: 1 US $ = 323Naira; SD is standard deviation

$$Logit\,(p) = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_i X_i + U_i \tag{2}$$

Where p denotes the probability of a child being stunted, wasted and/or underweight, β_i's are the parameter estimates of the explanatory variables, the X_i's represent the explanatory variables and U_i's are the stochastic error terms.

3 Results

3.1 Representation of Farm Household and Under-Five Children-Centred Factors

The results of study in Table1 reveals the description of farm households and under-5 children factors. The results show that 46% were male (boys). The average age was 33 months. 73% of the household head (HH) were men. The average age of HH stood at 49 years, indicating larger percent of household heads were above 40 years.

The average household size was 6 persons while HH education was about 7 years while average year of schooling of mother was below 6 (4.9 years). Likewise, the average farm income and non-farm income stood at 139, 250Naira (431 US $) and 66, 250Naira (205 US $) per year respectively. The average household expenditure on food stood at 21, 892Naira (68 US$). The body mass index (BMI) of the mother

which symbolizes overall nutritional standard of the mother and it is of great importance to the child nutrition. Their mean BMI was 24.1 which falls within the normal weight of 18.5-24.9kg/m^2.

3.2 The Commercialization Levels

The commercialization levels of farm households showed the extent of cassava commercialization of individual arm household. The commercialization level is estimated using the CCI of the individual cassava farmers as specified earlier (Eq.1). The findings indicated 9.2% and 16.1% of households are non-participants in the sales of the produce in the market (zero level) in the two states. However, close to half (49.7%) of the farm households recorded CCI > 75% in Ogun state and about 34% in Oyo state. Likewise, 40.1% of the households were categorized as very-high CCI.

3.3 Nutrition Outcomes of Under-Five Children of Farm Households

The results of the study in Table2 shows the nutrition outcomes of the young children of farm households. It revealed that only 6 children were in the age of 5 months while highest was 41 children under the age group 48–59 months. It also shows the mean and standard deviation of under-five WAZ, HAZ and WHZ were −0.21 ± 1.33, -1.59 ± 2.20 and 1.04 ± 1.71 respectively. Table2 also showed the nutrition outcomes of farm households' under-five children which shows that the prevalence (severe level in parenthesis) of stunting, underweight and wasting were 42.9% (25.0%), 7.9% (2.1%) and 3.6% (0.7%) respectively. However, Figs.1, 2 and 3 show the distribution of the cassava farm households' under-five children's nutrition outcomes in rural Ogun and Oyo States.

3.3.1 Gender-based Nutrition Outcomes of Under-Five Children of Farm Households

The findings indicated that there were 65 male (boys) under-five children in the sampled cassava farm households in six age groups (Table3) with children between age group 36–49 and 48–59 months having the highest number, 35 (53.8%). The average and SD of WAZ, HAZ and WHZ were −0.46 ± 1.31, -2.08 ± 2.32 and 1.10 ± 1.83 respectively. Meanwhile, nutrition outcomes of the male (boys) under-five children which indicated that the prevalence (severe level in parenthesis) of stunting, underweight and wasting were 49.2% (35.4%), 10.8% (4.6%) and 4.6% (0%) respectively. About 67 and 60% of male under-five children in the age groups 36–47 and 6–11 months were stunted respectively while lowest stunting prevalence (23.5%) was found in the age group 48–59 months. Table3 also revealed that highest underweight prevalence (40%) was found in male (boys) under-five (6–11 months) while 24–35 months of age (boys) recorded zero underweight prevalence. About 7% of male under-five children of age group 12–23 months were wasted while zero wasting prevalence was found in age groups 0–5, 24–35 and 36–47 months respectively.

Moreover, Table4 indicated that there were 75 female (girls) under-five children in the cassava farm households in six age groups as mentioned earlier with 10 (13.3%) children falling in age group 0–5 and 6–19 months while the highest number (46,

Table 2 Nutrition outcomes of under under-five children of farm households

Age Group (Months)		WAZ (%)				HAZ (%)				WHZ (%)			
	n	**%<-3SD**	**%<-2SD**	**Mean**	**SD**	**% <-3SD**	**%<-2SD**	**Mean**	**SD**	**%<-3SD**	**% <-2SD**	**Mean**	**SD**
0–5	6	0	25	-0.7	2.18	25	75	-2.08	2.73	0	0	1.53	2.41
6–11	14	0	16.7	-0.88	1.36	33.3	58.3	-2.27	2.2	0	8.3	0.84	1.81
12–23	30	0	3.6	0.38	1.34	21.4	46.4	-1.15	2.49	0	3.6	1.27	1.51
24–35	14	0	0	0.4	1.17	13.3	40	-1.29	2.19	0	6.7	1.52	1.88
36–47	35	2.7	5.4	-0.19	1.2	37.8	48.6	-1.88	2.35	0	0	1.34	1.62
48–59	41	4.5	11.4	-0.6	1.2	18.2	29.5	-1.51	1.85	2.3	4.5	0.49	1.71
Total (0–59)	140	2.1	7.9	-0.21	1.33	25	42.9	-1.59	2.2	0.7	3.6	1.04	1.71

Source: underlying survey data 2020

Note: Underweight and severe underweight in under-five children is WAZ < -2SD; < -3SD respectively

Stunting and severe stunting under-five children is HAZ < -2SD; < -3SD respectively

Wasting and severe wasting under-five children is WHZ < -2SD; < -3SD respectively; SD means Standard Deviation

61.3%) of female children were found in age group 36–49 and 48–59 months. The average and SD of WAZ, HAZ and WHZ were 0 ± 1.31, -1.17 ± 2.01 and 0.99 ± 1.61 respectively. Furthermore, the nutritional status of the girls indicated that the prevalence (severe level in parenthesis) of stunting, underweight and wasting were 37.3% (16.0%), 5.3% (0%) and 2.7% (1.3%) respectively.

However, about 57 and 32% of female under-five children in age groups 6–11 and 36–47 months were stunted respectively while highest stunting prevalence was found in 0–5 months. About 11% of female under-five children (48–59 months) were underweight while zero underweight prevalence was found in age groups 6–11, 12–23, 24–35 and 36–47 months respectively. Also, 16.7 and 3.7% of girls aged 24–35 and 48–59 months were wasted respectively while the rest of the age groups recorded zero wasting prevalence among girls belonging to the farm households in the study areas. Figures4, 5 and 6 show the distribution of three nutrition outcomes (HAZ, WAZ and WHZ) of the sexes (boys, n = 65, girls, n = 75) of young children of farm households in two states. The z-scores were compared with the WHO child growth reference population. The graphs were generated from WHO Anthro software using the children anthropometric measurements.

3.4 The Prevalence of Under-five Children's Malnutrition Across Farm Households' CCI Levels

This section explored the link between of cassava commercialization and nutritional status of children members of farm households. It further showed the relationship between cassava commercialization and nutrition indices of under-five members of the farm households. Anthropometric indices were used to measure under-five nutritional status. The results in Table5 showed that all farm household CCI levels had very low prevalence (< 8%) of wasted children but considering the category with highest prevalence of wasting, very-high CCI level (very-high level) recorded the highest (7%). However, highest stunting prevalence (64%) was recorded in zero level households while those regarded as high-level commercialization households (medium-high and very-high levels) also recorded very high stunting (medium-high level = 44%; very-high level = 38%) prevalence among under-five of cassava farm households. The findings indicated that belonging to high-level commercialization household may not translate to better nutrition among young children of farm households. Interestingly, low level households recorded zero (0%) underweight prevalence while about 8% underweight was found in all the under 5-year children used for this study (Table5).

Furthermore, results from the scatter plots (Figs.7, 8 and 9) showed the relationships between under-five nutrition outcomes (HAZ, WAZ, and WHZ) and CCI. The scatter plot in Fig.7 showed a weak positive relationship between HAZ and CCI with Correlation Coefficient (r) = 0.1450. Also, there existed a weak negative relationship between WHZ and CCI with (r) = -0.2091 while we found very weak negative association between WAZ and CCI with (r) = -0.0623.

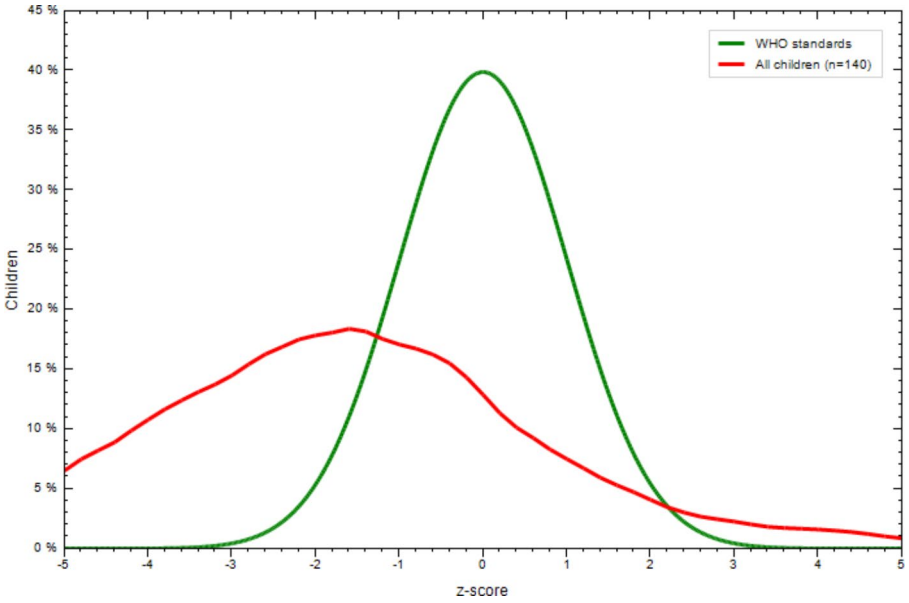

Fig. 1 Height-for-age z-score (HAZ) of all cassava farm households' under-five children (n = 140) in rural Ogun and Oyo States. Note: The red line is all children (n = 140) and the green line is the WHO 2007 child growth standards. HAZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

3.5 Determinants of Under-five Nutritional Status of Cassava Farm Households

This section presents results logit regression of drivers of under-five nutritional status (stunting, wasting and underweight) of farm households (Table6). As specified above, logit regression was used to regress nutritional status against some sets of household and child-centred variables (as regressors). The regressand in each case is a dummy, 1 if child is malnourished and zero if not (i.e. stunted, underweight or wasted = 1 and 0 if otherwise). The resulting parameter estimates from the logit regression indicate the possibility of the child being malnourished. However, noting that a positive sign on the coefficient indicates increased malnutrition, while a negative sign shows reduction in incidence of under-five malnutrition.

However, first section of the table reveals the results of the factors influencing stunting in cassava farm households. The results reveal that child's age is positively related to the likelihood of stunting, indicating the likelihood that older children will be stunted. The results also reveal that farm size are positively related to the likelihood of under-five stunting and being underweight but negatively related to the probability of wasting. Access to electricity, healthcare and crop sold ratio (commercialization) were positively related to the probability of stunting, underweight and stunting respectively. Consequently, access to electricity, crop sold ratio (commercialization level) and toilet access were negatively related to the likelihood of under-five's underweight, wasting and underweight respectively.

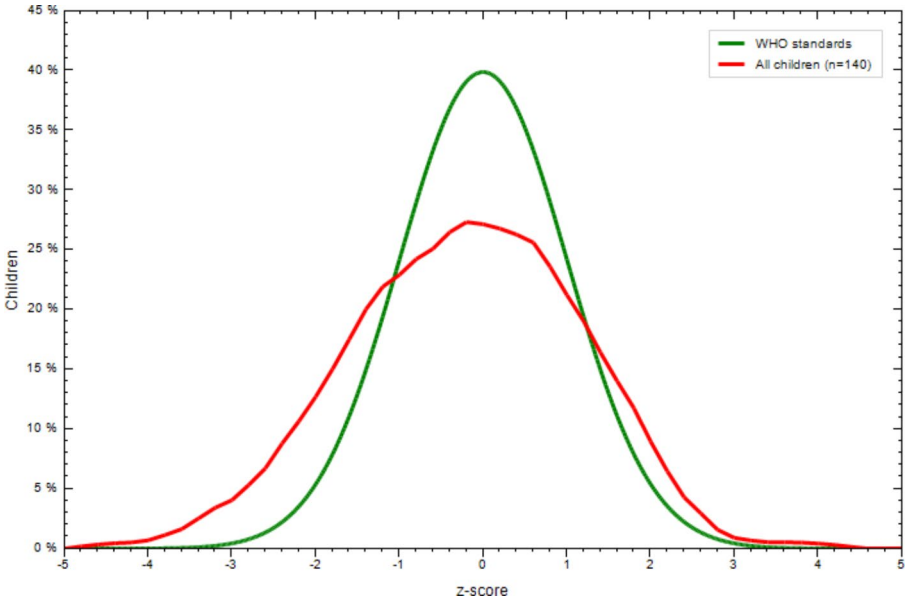

Fig. 2 Weight-for-age z-score (WAZ) of all cassava farm households' under-five children (n = 140) in rural Ogun and Oyo States. Note: The red line is all children (n = 140) and the green line is the WHO 2007 child growth standards. WAZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

4 Discussion

This nutritional status of the under-5 children members of farm households in the study areas revealed that the percentage of stunted under-5 children is however higher than the national average of 32.0% estimated from the National Nutrition and Health Survey (NNHS) 2018. This result is higher than the report of 23.6% by (Babatunde et al., 2011) in rural Kwara State while it was lower than that of Brhane & Regassa (2014) and Ogunnaike et al., (2020) who found 55.9% and 70% stunting among under-five children in rural Kwara and Ogun States respectively. About 8% of the under-five of cassava farming households were underweight while about 4% were wasted. Both percentage incidences of underweight and wasted of under-five children in this study were lower than the national average of 19.9% and 7.0% respectively (NNHS 2018). The result was consistent with Ukegbu & Ogu (2017) who recorded less than 5% (2.7%) underweight. Carletto et al., (2017) also found wasting prevalence of below 10% in under-five children in three African countries study.

Moreover, the result also revealed that the highest stunted under-five children (64.7%) were found in zero commercialization households (CCI 1) but highly commercialized households (medium-high (CCI 3 and very high (CCI 4) also recorded higher percent stunted children (44.2% and 37.7% respectively). Carletto et al., (2017) equally found high prevalence of under-five stunting in three African countries (Tanzania, 42%; Uganda, 36%; and Malawi, 31%) while findings by Okezie & Nwosu (2007) reported that children in cocoa growing households that were more

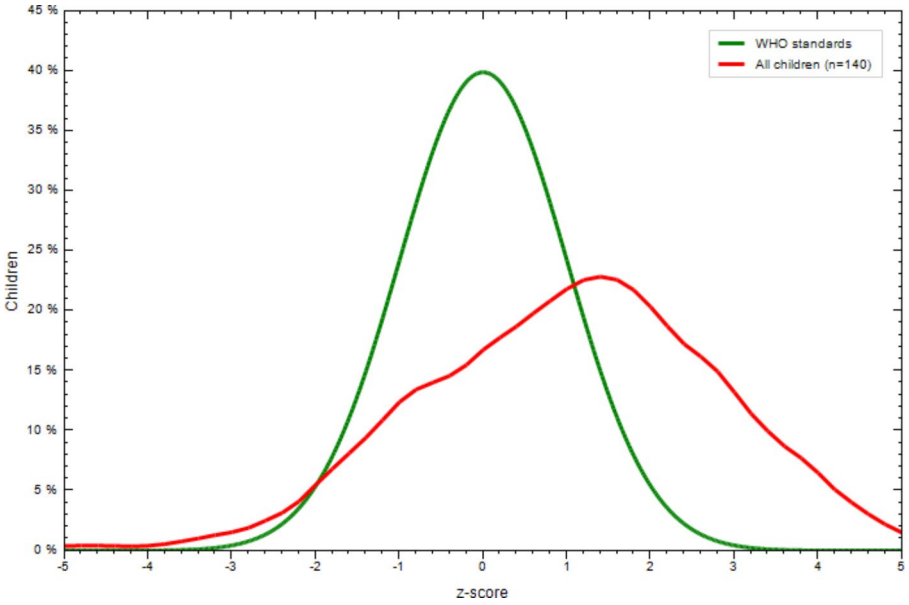

Fig. 3 Weight-for-height z-score (WHZ) of all cassava farm households' under-five children (n = 140) in rural Ogun and Oyo States. Note: The red line is all children (n = 140) and the green line is the WHO 2007 child growth standards. WHZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

commercialized recorded a higher prevalence of stunting and underweight. The Table6 also revealed that all commercialization household categories recorded very low prevalence of underweight (< 10%).

However, findings from the scatter plot (Fig.7) between HAZ and CCI indicated the existence of a weak positive association (r = 0.1450) between HAZ and CCI and revealing that as CCI increases, children HAZ (prevalence of stunting) may also go up. Also, scatter plot (Fig.8) between WHZ and CCI indicated the existence of negative relationship (r = -0.2091) between WHZ and CCI and indicating that as CCI increases, children WHZ (wasting) may go down. However, scatter plot in Fig.9 showed similar negative association between WAZ (underweight) and CCI but was abysmally weak (r = -0.0623). This equally indicated that as CCI increases, WAZ (wasting prevalence) among children under-5 may likely go down. These results was corroborated by the findings in Table5 which revealed that belonging to low level or high-level cassava commercialization households does not translate to better nutritional status of under-five children of rural farm households. For example, high stunting prevalence was found in both zero level (CCI 1) and very-high commercialization households. This revealed that both farm households of zero (CCI 1) and high-level (CCI 3 &4) commercialization recorded very high stunting prevalence (38–65%) among under-five children. However, belonging to zero/low level commercialization farm households or highly commercialized households does not translate to better nutritional status of members of the farm households especially the under-five children. Consequently, there is a need for the farm households (especially the household

Table 3 Under-five children (boys) nutrition outcomes among farm households

Age Group (Months)		WAZ (%)				HAZ (%)				WHZ (%)			
	No	**%<-3SD**	**% <-2SD**	**Mean**	**SD**	**%<-3SD**	**%<-2SD**	**Mean**	**SD**	**%<-3SD**	**%<-2SD**	**Mean**	**SD**
0–5	1	0	0	-1.35	0	100	100	-5.24	0	0	0	4.54	0
6–11	5	0	40	-1.52	1.11	60	60	-3.06	1.42	0	20	0.48	1.99
12–23	15	0	6.7	-0.19	1.27	20	53.3	-1.29	2.6	0	6.7	0.6	1.48
24–35	9	0	0	0.5	1.05	22.2	44.4	-1.26	2.79	0	0	1.69	1.67
36–47	18	5.6	11.1	-0.59	1.2	55.6	66.7	-3.1	1.92	0	0	1.81	1.58
48–59	17	11.8	11.8	-0.71	1.42	23.5	23.5	-1.67	2.03	0	5.9	0.46	2.05
Total (0–59)	65	4.6	10.8	-0.46	1.31	35.4	49.2	-2.08	2.32	0	4.6	1.1	1.83

Source: underlying survey data 2020.

Note: Underweight and severe underweight in under-five children is WAZ < -2SD; < -3SD respectively.

Stunting and severe stunting under-five children is HAZ < -2SD; < -3SD respectively.

Wasting and severe wasting under-five children is WHZ < -2SD; < -3SD respectively; SD means Standard Deviation.

Table 4 Under-five children (girls) nutrition outcomes among farm households

Age Group (Months)	WAZ (%)					HAZ (%)				WHZ (%)			
	No	**% <-3SD**	**% <-2SD**	**Mean**	**SD**	**% <-3SD**	**% <-2SD**	**Mean**	**SD**	**% <-3SD**	**% <-2SD**	**Mean**	**SD**
0–5	3	0	33.3	-0.48	2.61	0	66.7	-1.03	2.13	0	0	0.53	1.64
6–11	7	0	0	-0.42	1.41	14.3	57.1	-1.7	2.57	0	0	1.1	1.78
12–23	13	0	0	1.03	1.14	23.1	38.5	-0.98	2.46	0	0	2.05	1.14
24–35	6	0	0	0.24	1.42	0	33.3	-1.34	1	0	16.7	1.27	2.31
36–47	19	0	0	0.2	1.1	21.1	31.6	-0.72	2.16	0	0	0.9	1.57
48–59	27	0	11.1	-0.53	1.07	14.8	33.3	-1.41	1.76	3.7	3.7	0.51	1.51
Total (0–59)	75	0	5.3	0	1.31	16	37.3	-1.17	2.01	1.3	2.7	0.99	1.61

Source: underlying survey data 2020.

Note: Underweight and severe underweight in under-five children is WAZ < -2SD; < -3SD respectively.

Stunting and severe stunting under-five children is HAZ < -2SD; < -3SD respectively.

Wasting and severe wasting under-five children is WHZ < -2SD; < -3SD respectively; SD means Standard Deviation.

heads) to make concerted effort in providing high-quality food items for household members in order to improve their nutritional status especially the young children. All the revenue from the cassava production/marketing should not be completely ploughed back to the cassava enterprise but part should be spent on making high-quality foods available in the households which is capable of improving the diet quality of the households (Otekunrin, 2022).

However, this result was different from the findings of Carletto et al., (2017) who found no clear trends between HAZ and CCI using under-five children data from three African countries.

The results of the determinants of under-five malnutrition of cassava farming households (Table7) can be compared with previous studies such as that of Smith et al., (2005) who employed child z-scores as the dependent variable and used ordinary least square (OLS) regression model while Babatunde et al., (2011) and Ogunnaike et al., (2020) used the malnutrition category as the regressand and employed Logit regression model. The first section of the table reveals the results of the factors influencing stunting in cassava farm households. The results reveal that child's age is positively related to the probability of stunting, indicating the likelihood that older children will be stunted when all other factors are held constant. This finding is supported by Sarmistha (1999), Kabubo-Mariara et al., (2006) and Babatunde et al., (2011). This is not unconnected to the fact that many younger children are still on breast milk and may not be experiencing chronic malnutrition but until after weaning (Babatunde & Qaim, 2010, Otekunrin,).

The marginal effects of commercialization indicates that a unit increase in commercialization (crop sold ratio) increases the probability of stunted under-five children by 41.1% while a unit increase in commercialization reduces the probability of having wasted under-five children by 2.5% giving that that all other factors are held constant.

Also, the higher the farm income, the lower the probability of having household under-five stunting. Furthermore, a unit increase in farm size (Ha) increases the probability of under-five being stunted and underweight by 17.7 and 1.8% respectively giving that other factors are held constant. Meanwhile, a unit increase in farm size (Ha) reduces the probability of wasted under-five children by 0.05%. When access to electricity go up by 1% point, the probability of experiencing stunting in under-five children increases by 24.3% but the probability of experiencing underweight (>-2 SD) reduces by 14.1%. Similarly, household access to toilet reduces the probability of underweight in under-five children giving that other factors are held constant.

5 Conclusions

Previous studies that analyzed factors influencing under-five malnutrition but works on links between cassava commercialization households and malnutrition in under-five children are limited in Nigeria. In our study, we investigated the nutrition outcomes of under 5 year's children among cassava farm households in Nigeria. The CCI categorized farm households into four levels, WHO Anthro software was used to obtain anthropometric indices while logit regression model was employed to analyze

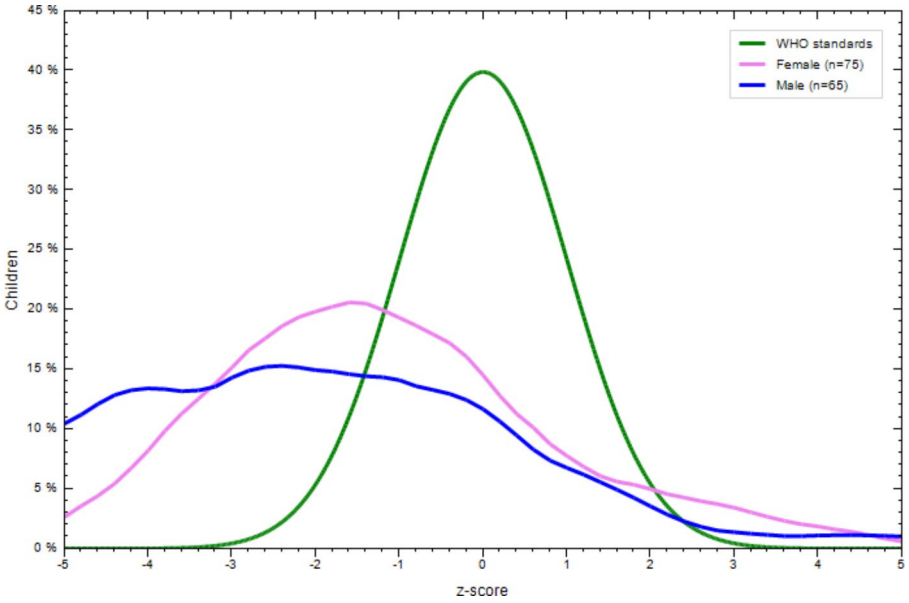

Fig. 4 Height-for-age z-score (HAZ) of gender (boys and girls) of cassava farm households' under-five children in rural Ogun and Oyo States. Note: The pink line is the female children (n = 75), the blue line is the male children (n = 65), while the green line is the WHO 2007 child growth standards. HAZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

the drivers of under-five malnutrition on cassava commercialization farm households in the study areas.

Crop commercialization index was estimated for each cassava farming households and the incidence of malnutrition in under-five children was also assessed across all the four commercialization household levels. Logit regression analysis was based on three nutritional status (stunting, underweight and wasting).

Logit regression analysis revealed that child's age, farm size, access to electricity, toilet, healthcare and crop commercialization variable (crop sold ratio) were among the significant determinants of child malnutrition. The study found somewhat weak association between the under-five children's nutritional outcomes (HAZ, WAZ and WHZ) and degree of crop commercialization in the sampled smallholder cassava farming households.

Therefore, to contribute to the mapping out of policies aimed at reducing the prevalence of malnutrition among children in rural settings. This study recommended maternal nutrition-sensitive education interventions and provision of rural infrastructures such as potable water, healthcare, toilet and electricity which are crucial to increased farm production and quality of life of the rural households especially the young children.

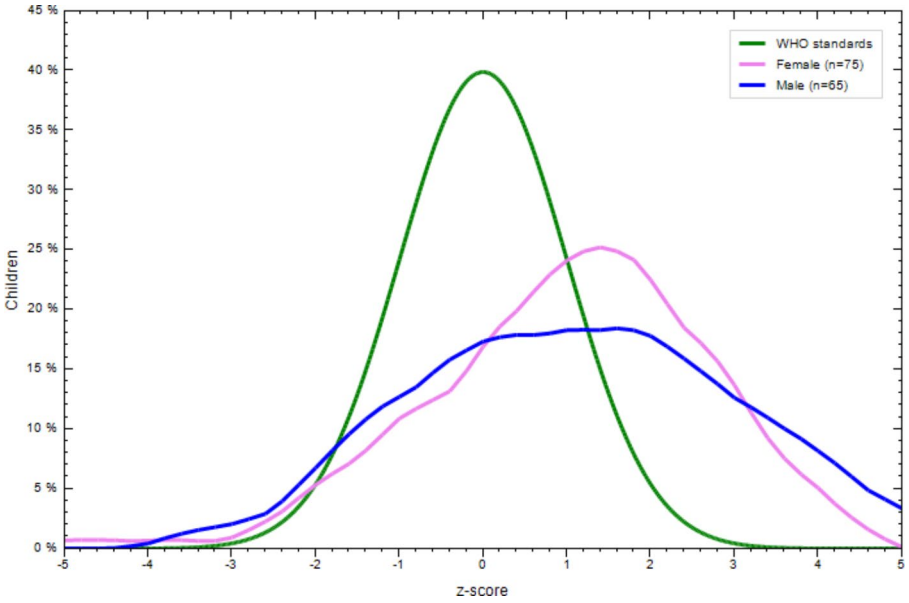

Fig. 5 Weight-for-height z-score (WHZ) of gender (boys and girls) of cassava farm households' under-five children in rural Ogun and Oyo States. Note: The pink line is the female children (n=75), the blue line is the male children (n=65), while the green line is the WHO 2007 child growth standards. WHZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

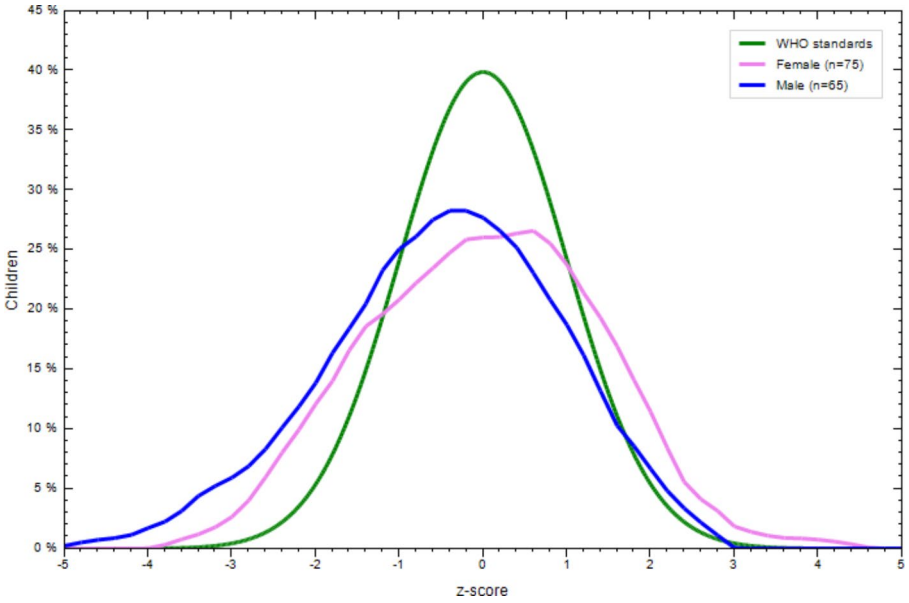

Fig. 6 Weight-for-age z-score (WHZ) of gender (boys and girls) of cassava farm households' under-five children in rural Ogun and Oyo States. Note: The pink line is the female children (n=75), the blue line is the male children (n=65), while the green line is the WHO 2007 child growth standards. WAZ are compared with the WHO child growth reference population. Source: Authors' graph generated from WHO Anthro software

Table 5 Under-five nutritional status across farm households' CCI levels

	Crop Commercialization Index (CCI) Levels				
	Zero Level	**Low Level**	**Medium-High Level**	**Very High Level**	**Pooled**
Nutritional Status	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Wasted < −2 SD	0 (0.0)	0 (0.0)	1 (1.9)	4 (6.6)	5 (3.6)
Not wasted > -2 SD	17 (0.0)	10 (0.0)	51 (98.1)	57 (93.4)	135 (93.4)
Total	17 (100)	10 (100)	52 (100)	61 (100)	140 (100)
Stunted < −2 SD	11 (64.7)	3 (30.0)	23 (44.2)	23 (37.7)	60 (42.9)
Not stunted > -2 SD	6 (35.3)	7 (70.0)	29 (55.8)	38 (62.6)	80 (57.1)
Total	17 (100)	10 (100)	52 (100)	61 (100)	140 (100)
Underweight < −2 SD	1 (5.9)	0 (0.0)	5 (9.6)	5 (8.2)	11 (7.9)
Not underweight > -2 SD	16 (94.1)	10 (100)	47 (90.4)	56 (91.8)	129 (92.1)
Total	17 (100)	10 (100)	52 (100)	61 (100)	140 (100)

Source: Underlying survey data, 2020 Note: SD = Standard Deviation

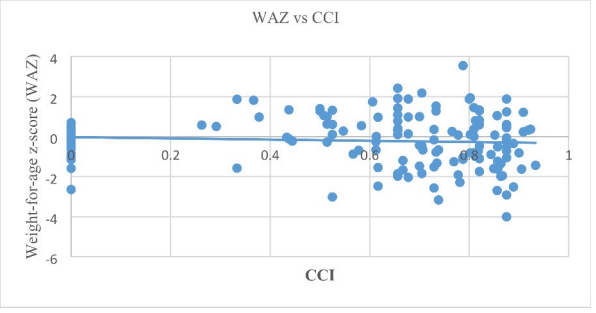

Fig. 8 Association between WAZ and CCI

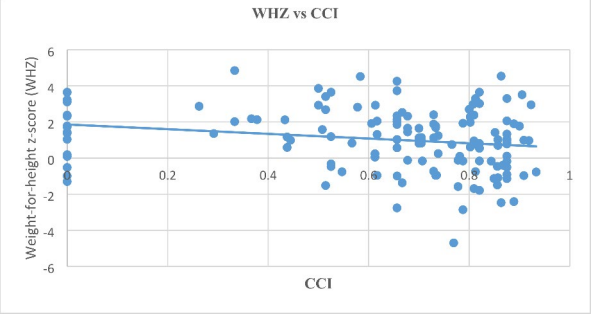

Fig. 9 Association between WHZ and CCI

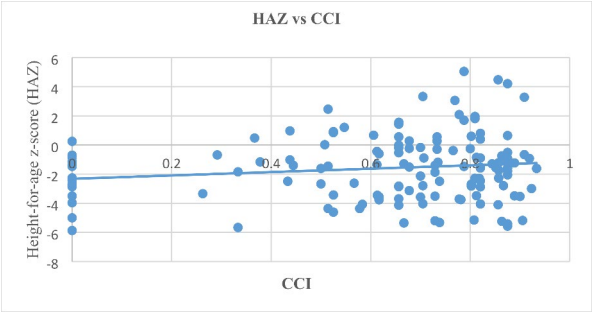

Fig. 7 Association between HAZ and CCI

Table 6 Determinants of under-five nutritional status

	Under-five nutritional status					
	Stunting (1)		**Underweight (2)**		**Wasting (3)**	
Variables	**Estimated β values (SE)**	**Marginal Effects**	**Estimated β values (RSE)**	**Marginal Effects**	**Estimated β values (RSE)**	**Marginal Effects**
Child Age (Months)	0.0394***	0.0096	0.0254	0.0002	-0.0064	-0.00003
	(0.0115)		(0.0261)		(0.0356)	
+Child Gender	0.6160	0.1491	-0.0553	-0.0005	-0.7503	-0.0031
	(0.4602)		(0.8742)		(0.7423)	
Mothers' Age	0.0123	0.0030	-0.0320	-0.0003	-0.0408	-0.0002
	(0.0213)		(0.0306)		(0.0431)	
Household Size (Number)	-0.0475	-0.0115	0.2103	0.0019	-0.1866	-0.0008
	(0.0873)		(0.1877)		(0.3132)	
Farm Size (Ha)	0.7263*	0.1765	1.9954**	0.0184	-1.1728**	-0.0049
	(0.3741)		(0.8887)		(0.5305)	
HH year of schooling	-	-	0.1894*	0.0017	-0.1349	-0.0006
			0.1102		(0.1655)	
Mothers' year of schooling	0.0119	0.0029	0.0782	0.0007	0.2119	0.0009
	(0.0552)		(0.1549)		(0.3926)	
Farm Income (Naira)	-5.13e-06*	-1.25e-06	-7.83e-06	-7.21e-08	0.00002*	1.01e-07
	(2.98e-06)		(4.88e-06)		(0.00001)	
Nonfarm Income (Naira)	8.73e-08	2.12e-08	5.12e-06	4.72e-08	0.00002	9.66e-08
	(3.20e-06)		(6.88e-06)		(0.00002)	
Food Expenditure (Naira)	-0.00004	-8.48e-06	0.00003	3.08e-07	0.00003	1.23e-07
	(0.00003)		(0.00006)		(0.00006)	
+Mothers' Nutrition Training	0.8631	0.1951	1.659	0.0103	0.2716	0.0010
	(0.5480)		(1.0790)		(0.9431)	
+Access to Electricity	1.0577*	0.2428	-4.2860***	-0.1406	-	-
	(0.5904)		(1.0442)			
+Access to Toilet	-0.3472	-0.0853	-1.6261**	-0.0254	-0.5687	-0.0028
	(0.5723)		(0.6728)		(1.2110)	
+Access to Piped water	-1.3495*	-0.3224	-	-	-	-
	(0.8005)					
+Access to Healthcare	-	-	3.7058***	0.0704	-	-
			(1.1102)			
Crop sold ratio	1.6901**	0.4107	-1.8197	-0.0168	-5.9321*	-0.0248
	(0.8405)		(1.9874)		(3.1422)	

Table 6 (continued)

	Under-five nutritional status		
Constant	-2.4541	-0.1181	8.6022***
	(1.1408)	2.3636	(2.4532)
Number of observations	140	140	140
Wald chi^2 (20)	23.98	38.74	29.71
Prob > chi^2	0.0461	0.0007	0.0052
Log pseudo likelihood	-82.368667	-26.685637	-15.982256
Pseudo R^2	0.1385	0.3075	0.2591

(+) represent dummy variable (0 or 1). ***Significance at 1% level, **Significance at 5% level, *Significance at 10% level. SE means Standard Error; RSE means Robust Standard Error.

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Author contribution Conceptualization, Olutosin A. Otekunrin; Methodology, writing-original draft preparation, Olutosin A. Otekunrin; Oluwaseun A. Otekunrin; Writing- reviewing and editing, Olutosin A. Otekunrin; Oluwaseun A. Otekunrin. The authors have read and agreed to the published version of the manuscript.

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Data Availability The study utilized primary data and are available upon request from the authors.

Declarations

Ethics Approval and Consent to Participate The study was approved by the Department of Agricultural Economics and Farm Management Review Board of Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria. Additionally, this study was approved by the Oyo State Ethics Review Committee of the Ministry of Health Ref No: AD13/479/4420[A]. Informed consent was obtained from the respondents before the survey was carried out.

Consent for Publication Not applicable.

Competing Interests The authors declare that they have no competing interests.

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