World Development Sustainability 4 (2024) 100158

Contents lists available at ScienceDirect

World Development Sustainability

journal homepage: www.elsevier.com/locate/wds

Effects of food price changes on child undernutrition among agricultural households in Nigeria

Dare Akerele [a,*], Olusegun Fadare [b], Adebayo Ogunniyi [c], Olutayo Adeyemi [d], Mistura Rufai [e]

[a] Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Nigeria
[b] Livelihoods and Institutions Department, Natural Resources Institute, University of Greenwich, Medway Campus, Chatham Maritime, Kent ME4 4 TB, UK
[c] United Nations – International Fund for Agricultural Development, Abuja, Nigeria
[d] Department of Human Nutrition, University of Ibadan, Ibadan, Nigeria
[e] Health, Education and Agriculture Unit, World Bank Group, Abuja P.O. Box 2826, Nigeria

ARTICLE INFO

Keywords:
Food inflation
Chronic malnutrition
Acute malnutrition
Farm households
Africa

ABSTRACT

This study examines the effects of changing food prices on the nutritional outcomes of children under five years old in Nigeria, utilising data from the 2013 and 2016 Nigeria Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA). We applied correlated random-effects probit and fixed-effects regression models to analyse the data. Results indicate an increase in stunting and decreases in wasting and underweight conditions among children over the years studied. Specifically, higher prices for fish, eggs, beef, rice, and cooking oil have a significant association with increased stunting, while increases in the prices of maize and garri are associated with greater wasting. Underweight increase with higher prices of milk, maize, and rice. In contrast, modest increases in yam and beans prices have not exacerbated undernutrition. The study also highlights the importance of household income growth and women's involvement in financial decisions in reducing child undernutrition. We advocate for agriculture-led, nutrition-sensitive policies that address the high costs of animal proteins and staples such as rice, maize, and garri, while monitoring and carefully regulating upticks in the prices of yam and beans.

1. Introduction

Global efforts in recent decades have made significant strides in reducing childhood malnutrition. However, in Africa, the rate of malnutrition remains alarmingly high. As of 2022, approximately 43 % of children under five in this region are stunted, while about 27 % experience wasting [1]. Such malnutrition has implications that extend beyond immediate health concerns; it negatively affects children's school performance and can result in reduced economic productivity in adulthood [2]. Nigeria, in particular, faces a pressing malnutrition challenge, with 34.2 % of children under five years stunted in 2022, higher than 31.5 % reported for sub-Saharan Africa [1]. The country still currently holds the undesirable position of having the second-highest acute malnutrition rates globally [3]. Therefore, addressing child undernutrition in Nigeria is pivotal to improving the overall nutrition landscape in Africa.

A significant proportion of households in Nigeria face challenges such as poverty, hunger, and undernutrition, situations that are exacerbated during economic downturns and when there are spikes in food prices [4]. Available data indicate a consistent rise in food prices over the past decade. For instance, the consumer food price index climbed from 71.9 in 2007 to a staggering 278.2 by June 2018 [5-7] and skyrocketed to 590.24 in December 2022 [8]. The surge has primarily affected staples such as bread, rice, beans, garri and yam [9]. However, it remains an open question which specific foods or food groups prices have contributed to worsening nutrition outcomes among agricultural households in Nigeria. This is because the effects of rising food prices can be manifold and complex. The impact can vary based on their profiles and how internal and external labour and commodity markets react to such price fluctuations [10,11]. In addition, households generally adjust to a surge in food prices by shifting their food consumption towards relatively cheaper alternatives that could enable them to meet their nutritional needs.

This study primarily aimed to investigate the effects of food prices on agricultural households for several reasons. Firstly, agricultural households in Nigeria are largely concentrated in rural areas where child

* Corresponding author at: Department of Agricultural Economics and Farm Management, Federal University of Agriculture, Abeokuta, Nigeria.
E-mail address: akereled@funaab.edu.ng (D. Akerele).

https://doi.org/10.1016/j.wds.2024.100158
Received 8 May 2023; Received in revised form 2 May 2024; Accepted 19 May 2024
Available online 30 May 2024

undernutrition is more prevalent. For example, in Kwara State, Nigeria, Fadare et al. [12] reported a 56 % stunting prevalence among children under five in agricultural households based on 2014 survey data, while Otekunrin and Otekurin [13] reported a prevalence of up to 65 % in a later year. These values are higher than the national average of 37 % reported by USAID [14]. Regarding wasting, Ogunnaike et al. [15] reported a prevalence of 8 % among agricultural households, while Obayelu and Adeleye [16] reported about 11 % in rural Nigeria. These figures are slightly higher than the national average of 7 % [14].

Secondly, examining the effect of food price changes on undernutrition among agricultural households is not only of great significance for overall nutrition in the country, but doing this can also present an important entry point to design or reorient nutrition-sensitive, agriculture-led policy actions and other output market interventions that can affect food prices. This is crucial, especially since improved nutrition outcomes have been globally recognised as a key indicator for evaluating the performance of development interventions and progress towards the attainment of sustainable development goals.

Some of the policy efforts aimed at influencing food prices are enshrined in the National Agricultural Technology and Innovation Policy (2022–2027) .[1] These efforts focus on enhancing partnerships between the government and the private sector to improve and expand the capacity of the national strategic food reserve. This includes refining food procurement and buffer stock operations to reduce supply volatility and stabilise the prices of essential grains and other foods. The policy also includes direct market interventions aimed at purchasing foods at guaranteed minimum prices. Other policy instruments used to influence agricultural commodity prices, either directly or indirectly, include taxes levied at different points along the marketing chain, trade restrictions on food imports, exchange rate policies, and farm-level interventions aimed at enhancing agricultural productivity and stabilising staple food supply and prices. Findings from this study could provide important insights to guide such policy actions through a nutrition-focused lens.

Although several studies have assessed the effects of food price changes on household welfare in Nigeria [11,17,18], focusing on monetary metrics, there are still limited studies examining these effects on children's nutrition outcomes. An example is the study by Fajobi et al. [19], who examine the relationship between food prices and women's anthropometric measures using cross-sectional data. Our study aims to examine the relationship between food commodity prices and child nutrition in Nigeria, using panel data. We estimate the prevalence of child stunting, wasting, and underweight in agricultural households, and examine the effect of food price changes on these nutritional outcomes.

2. Literature review

In many developing countries, agricultural policies primarily focus on boosting farm production, often overlooking the impact of market factors, such as food price spikes, on nutritional outcomes. Over the last two decades, Nigeria has seen a consistent upward trend in food commodity prices. Data from the Central Bank of Nigeria's statistical bulletin (1995–2022) reveal a steady increase in the annual consumer food price index [8,20]. For instance, the food price index surged by over 200 % from 22.64 in 1995 to 66.85 in 2005 and more than doubled again from 141.19 in 2012 to 590.24 in 2022 (see Fig. 1). Nevertheless, the link between these price escalations and nutrition remains understudied.

In a more recent study, Headey and Ruel [21] explored the influence of food inflation on child undernutrition in low- and middle-income countries (LMICs), specifically studying wasting and stunting. They combined data from 130 Demographic Health Surveys across 44 LMICs, spanning from 2000 to 2021, with national food price data. They found that a 5 % increase in food prices raised the risk of wasting by 9 % and severe wasting by 14 %, especially among children from poor rural households. Their study suggests that food inflation during pregnancy and a child's first year can increase the risks of stunting due to prenatal factors and long-term effects on growth, primarily driven by reduced maternal and child dietary quality rather than direct health issues. While the study's broad sample and innovative methods strengthen its findings, its observational nature limits the ability to establish a direct link between food inflation and undernutrition.

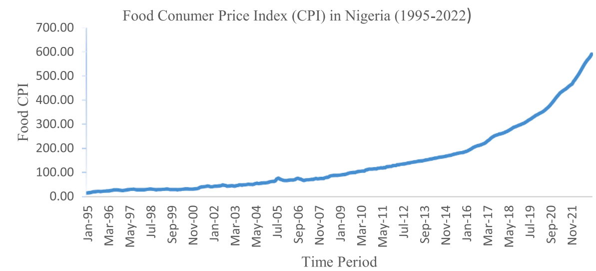

Fig. 1. Trend of food consumer price index in Nigeria, 1995 to 2022.
Source: Authors' computation from price data of the Central Bank of Nigeria [8]

In Nigeria, Shittu et al. [17] investigated the welfare effects of food spikes among Nigerian households using a nationally representative dataset. They found a negative association between spikes in cereals prices and the calorie and value of food consumed by households. Nonetheless, the connection with nutritional outcomes remained elusive. Examining the implications of food price increases on households in Nigeria, studies by Obayelu [22] and Olomola [23] provide significant insights. Obayelu [22] explored the effect of food price hikes on household nutritional status within two Nigerian states, revealing that as a coping mechanism, households often reduced their daily food consumption in terms of frequency and portion size. However, this study used food consumption as a proxy for nutrition, which may not capture the full spectrum of nutritional outcomes.

Olomola [23] adopted a broader approach, investigating the impact of the 2008 global food price crisis on various welfare indicators in Nigeria. His-study found that the gap between recommended and actual per capita daily protein and calorie intake became more pronounced during this crisis. Both studies revealed the potential implications of food price changes on dietary intake. However, within the broader context of nutrition outcomes, Fajobi et al. [19] examined the effects of food price on obesity, overweight and underweight among women in Nigeria.

Historically, Nigerian farmers have faced inefficiencies with the Commodity Board and Licensed Buying Agents, which led to diminished agricultural outputs and occupational shifts. In response, the marketing boards were abolished in 1986 to allow for market-driven price determination [24]. Subsequent governments have utilised agricultural input subsidies to boost production and regulate food prices. More recently, there has been a shift towards incentive-based product pricing strategies [4]. While Nigeria's agricultural and trade policies have attempted to address food price concerns, their impact on nutrition remains intricate. Comprehensive studies are essential to develop policies that improve the nutritional status of young children in Nigeria.

3. Conceptual framework

The conceptual framework adopted here is drawn from the work of Dangour et al. [25], which explores the linkage between food-price-related agricultural policies and nutritional status. These policies are agricultural policy levers capable of altering food prices and,

[1] Federal Ministry of Agriculture and Rural Development. (2022). National Agricultural Technology and Innovation Policy (NATIP) 2022-2027. Retrieved from www.fmard.gov.ng.

consequently, nutrition outcomes. As mentioned earlier, they are broadly labeled as output market interventions. This category includes buffer stock operations, guaranteed minimum price, and those policies affecting the price of food production in the long term, as well as those influencing trade policies. The intention here is to use the results of the analysis to draw policy implications for specific food items.

While there are several reinforcing or complementing policies and intervention pathways that connect to nutrition outcomes, the key policy interests in this study relate to the food-price-related pathway (highlighted in bold in Fig. 2). Food price policies influence nutrition through two major pathways: the first is the direct effects they have on food consumption through food prices, as consumers can shift to other less expensive alternatives. The second relates to the indirect effects through income generation. This is because more income can accrue to agricultural households who take advantage of the incentives provided by a price rise to attract more revenue. It is also worth mentioning that improvements in intra-household dynamics in decision making over income and child-specific characteristics such as age and sex may play role in determining child nutrition outcomes. The magnitude of the income that can be realised from sales of farm products, and the types, quantities, and quality of foods purchased in the markets, can also be substantially influenced by changes in food prices.

In the second pathway (income generation), after consuming foods from own production, households can sell the remaining farm outputs (surplus) in the market to earn income. The earnings realised from sales of the farm outputs, coupled with incomes from other sources, can then be used to buy more diverse foods in the market [25,26]. It is worth mentioning that for the purpose of this study, the conceptual framework presented is primarily focused on food price and related pathways to addressing nutritional outcomes. This is not to undermine other pathways of influence.

4. Data and empirical strategies

4.1. Data

This study uses the Nigeria Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) from 2012/13 and 2015/16. The survey is representative at both the geopolitical zone and national levels, encompassing data from households across Nigeria's 36 states and the Federal Capital Territory. The LSMS-ISA, a collaborative effort between the World Bank and the National Bureau of Statistics (NBS) [27], spans various aspects of household livelihoods. The surveys provide important information on child characteristics such as age, sex, weight, height, household size, and total household consumption-expenditure. In addition, data on food prices collected by the NBS, corresponding to the years, months, and locations of the LSMS-ISA survey data, were employed. The WHO Anthro V3.2.2 software was used to calculate child anthropometric measures.

For this study, a subset of data focusing on agricultural households was selected. The households chosen are those with at least one child who was two years old or younger during the post-harvest period in 2013 and no more than five years old in the post-harvest season of 2016. Each selected child belonged to the same household, had the same member's identifier, and was of the same sex in both 2013 and 2016. These children also had the same parent or caregiver, were in the same sector, state, and geopolitical zone in both years. Essentially, a specific child who was, for example, two years old in 2013, was followed to be no

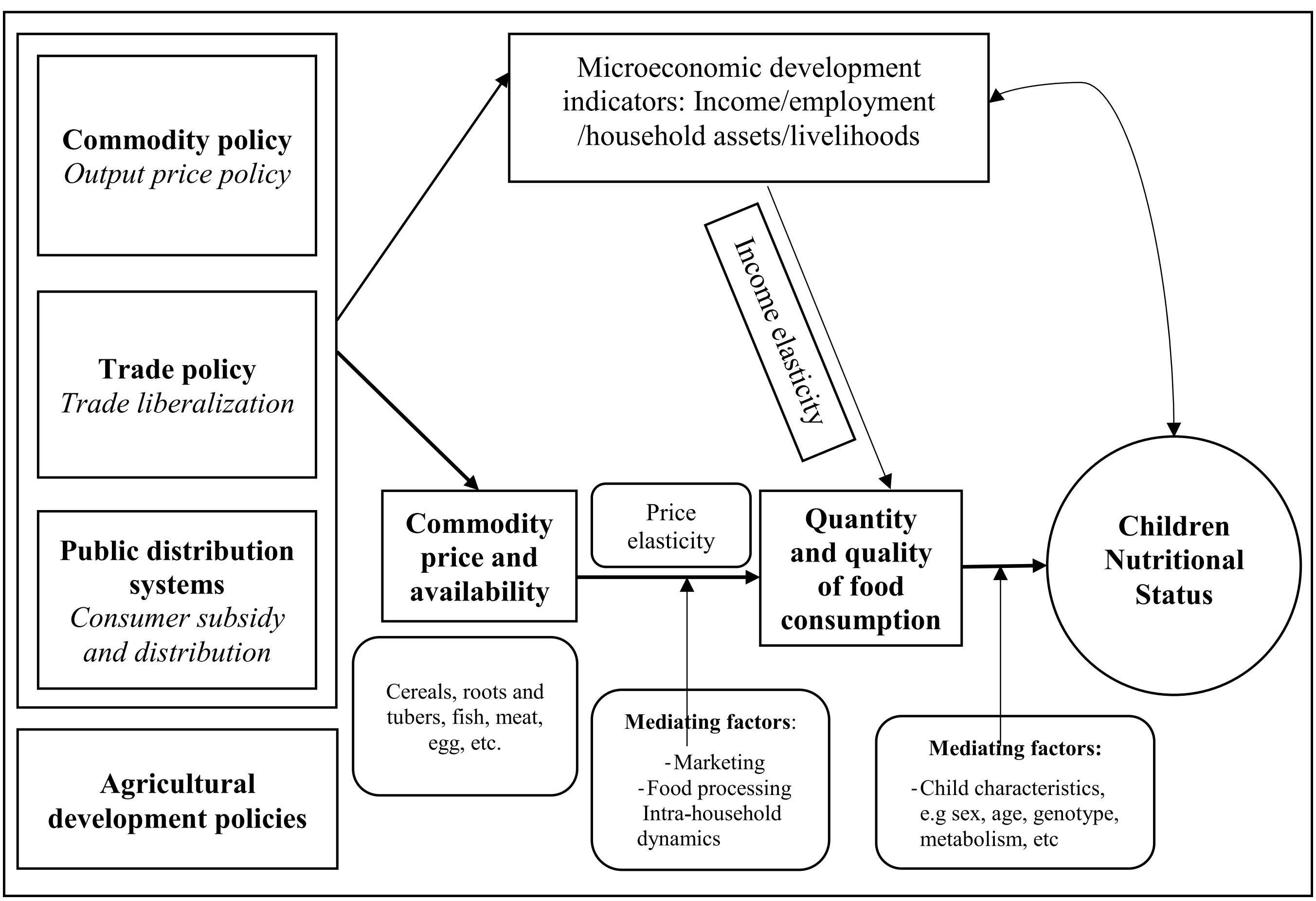

Fig. 2. Conceptual framework linking food-price-related agricultural policies to nutritional status.
Source: Adapted from Dangour et al. [25].

older than five years in 2016. There were 788 children 2 years old and below in 2013 but 303 of them did not participate (dropped out) in the survey in 2016. As a result, 485 children were successfully tracked from 2013 to 2016, totaling 970 observations across the two time periods. This could be a potential source of limitation to this work.

However, the external validity of the findings (based on the 970 observations) is less likely to be substantially affected by the observations that were lost in the children panel. This is because, using independent sample *t*-test, we compared the characteristics of those children that were 2 years old and below in 2013, but not found in the panel in 2016 with those traced to 2016. We find that the mean children anthropometric z-scores (WAZ, HAZ, and WHZ), age, prevalence of wasting and stunting and proportion of girl child between these two groups of children (2 years and below) are not significantly different from zero. Results are presented in Table S1 in the online supplementary material.

4.2. Empirical strategies

We assess undernutrition in children using anthropometric measures (age, weight, and height) by calculating the height-for-age z-scores (HAZ), weight-for-height z-scores (WHZ), and weight-for-age z-scores (WAZ) [28]. We compute the prevalence of stunting, wasting, and underweight conditions for the sampled children, respectively using HAZ, WHZ, and WAZ. Stunting is indicated by HAZ less than 2 standard deviations (SD) below the median of the reference population (HAZ < -2 SD), reflecting reduced linear growth in children [29]. On the other hand, wasting and underweight are indicated by WHZ and WAZ values less than 2 standard deviations below the median of the reference population (WHZ < -2 SD and WAZ < -2 SD, respectively) [29].

While stunting captures the chronic dimension of child malnutrition, wasting reflects the acute dimension, and underweight measures a general deficit in weight relative to the age of the child, which can result from either acute or chronic malnutrition. More importantly, wasting is widely employed for nutritional surveillance, especially in locations that are prone to multiple shocks. This is because it is an important marker of early nutritional impairments in children, which requires prompt attention, especially given its strong relationship with childhood mortality. Child stunting, on the other hand, captures the cumulative (longer-term) impacts of poor nutrition and recurrent cases of wasting.

We employ descriptive statistics to summarise the prevalence of these nutritional outcomes, and variables used in the analysis, comparing the two periods. For the regression analysis, we estimate a correlated random effect (CRE) probit regression model [30], to examine the impacts of changes in food prices on three measures of child undernutrition: stunting, wasting, and underweight. The model is essentially suitable for explaining the response probability between a binary outcome (variable) and some sets of covariates, idiosyncratic (time-varying) shocks and individual-specific unobserved characteristics, the complexity of which cannot be fully explored through analysis of cross-sectional data. This is because data on the observations for analysis extend beyond one period and contain more variability and efficiency than what is available in a single cross-sectional data.

We specify three separate regression models. Each model is dedicated to a specific nutritional outcome in children: one model evaluates the probability of a child experiencing stunting, another assesses the probability of wasting, and the third, the chances of being underweight. For each of these dimensions of child nutrition outcomes, we specify a CRE probit regression model as follows:

$$N^*_{it} = X_{it}\phi + c_i + e_{it},\ t = 1,\ 2,\ \ldots,\ \mathrm{T} \tag{1}$$

$$N_{it} = 1(N^*_{it} > 0)$$

$\boldsymbol{X}$ represents a matrix of explanatory variables that can be time-varying or time-constant. ϕ is the vector of coefficients associated with X_i. N^*_{it} is the latent variable determining whether a child *i* is experiencing stunting, wasting or underweight at time *t*. N_{it} is a dummy variable that equals one if child *i* in time t suffered stunting, and zero otherwise. The same operationalisation is done for wasting and underweight.

$$e_{it}|(X_{it},\ v_i) \sim\ N(0,1).$$

e_{it} represents the idiosyncratic shocks assumed to be serially uncorrelated, c_i is the unobserved household-specific heterogeneity assumed uncorrelated with the time-varying components of X_i. The correlated random effects probit framework permits c_i to depend on the time average of X_i as follows:

$$c_i = \ \delta + \ \overline{X_i}\phi + \ v_i,\ v_i|X_i \sim\ N\left(0, \sigma_v{}^2\right) \tag{2}$$

Combining Eqs. (1) and 2, the correlated random effects probit regression model is thus specified:

$$N^*_{it} = X_{it}\phi + \delta + \overline{X_i}\phi + v_i + e_{it} \tag{3}$$

Deriving from [31], the CRE can be specified to reflect the time-varying and time-constant components of explanatory variables $\boldsymbol{X}$= (G, **Z, V**) as follows:

$$N^*_{it} = G_t\Omega + Z_i\beta + \ V_{it}\varnothing + \delta + \overline{V_i}\vartheta + v_i + e_{it} \tag{4}$$

where **V** are the time-varying variables which include the main factors of interest – prices of food items, child age, proportion of crop sold, age of household head, income, women's financial decision-making index, dependency ratio, and whether (or not) the household sold livestock. G is a time dummy variable (equaling 1 for year 2016 and zero for 2013). Included in the time-constant covariates **Z** are a set of dummies depicting the sex of child, that of the household head, and the geopolitical zone where a child belongs. $\varnothing$ captures the within-cluster effect of the cluster-varying variables on N_{it} and ϑ reflects the difference between the between-cluster effects and within-cluster effects. Ω and β are coefficients associated with the time dummy and time-constant covariates, respectively. As noted by Wooldridge [30], the CRE model estimated using the pooled method is suitable for analysis if the serial independence assumption is relaxed and if the focus is to estimate the average partial (marginal) effects.

To further understand how changes in food prices influence incremental changes in a child's growth and weight patterns, we employ fixed-effects regression models on each of the anthropometric z-scores (HAZ, WHZ, and WAZ). We employed the continuous variable (z-scores) instead of the binary indicators of nutritional outcomes used in the CRE models to be able to consider the intensity dimension of the phenomenon, which might also be of interest to some readers. In addition, the fixed-effects models for the dichotomous variable are subject to incidental parameters challenge especially with a short time period ($T = 2$) as it is the case in this study. Employing a fixed-effects model allows for the control of unobserved, time-invariant characteristics inherent to each child, such as genetic factors or early childhood conditions, while analysing the effect of various factors on the outcomes. Thus, we specify the fixed-effects model as:

$$Y_{it} = \alpha + X_{it}\phi + \partial_i + \varepsilon_{it} \ (5)$$

where Y_{it} represents anthropometric indices of HAZ, WHZ, and WAZ of a child *i at* time *t* respectively. The intercept is α, and ϕ captures the coefficients of vector $\boldsymbol{X}$, variables already listed above. The ∂_i term captures the unobserved, time-invariant characteristics specific to each child, and ε_{it} is the idiosyncratic error term, which captures other unobserved factors that may affect child nutrition. Our focus is to examine the sensitivity of the stated dimensions of child undernutrition to a small (marginal) change in food prices. Hence, we use the original (untransformed) food price in the analysis in line with some studies such as Bedane [32] and Fajobi et al. [19] that have examined the influence of food price on nutritional outcomes – wasting, underweight, and/or stunting.

5. Results and discussion

5.1. Descriptive results

Presented in Table 1 are the summary statistics results, showing the mean differences in variables used for analysis, which include child nutrition outcomes, food prices, and various socioeconomic factors, between the 2013 and 2016 data. The data show that the prevalence of stunting in the sample averaged 35 %, wasting, 10 %, and underweight, 16 %, with mixed trends in these nutritional outcomes between 2013 and 2016. A significant decline in HAZ from −0.68 in 2013 to −1.26 in 2016 implies a greater deviation from the median height for age, reflecting falling conditions in child growth, and a slight increase in stunting prevalence from 34 % in 2013 to 36 % in 2016. The small rise in stunting is no surprise because the children also aged. Conversely, the mean WHZ statistically increased from −0.29 in 2013 to 0.12 in 2016, and WAZ showed a minimal change from −0.57 to −0.53.

These results reflect their prevalence, as wasting showed a significant drop from 13 % to 7 % and underweight was reduced in the same manner from 18 % to 14 %. The reduction in wasting may result from interventions or changes in conditions that affect short-term child nutrition, which is reflected in children weight gain compared to their age as measured by underweight. In general, the data show a mixed but largely positive picture, with significant improvement in reducing wasting and underweight conditions in sampled children, despite a slight increase in stunting prevalence. The persistently high prevalence of stunting in the country agrees with the reports by the National Population Commission (NPC) Nigeria and ICF International [33], UNICEF [34] and USAID [14].

The results further show that there were significant increases in the prices of staples such as sorghum, maize, bread, rice, yam and garri, and animal protein food items, including fish, milk, and beef. These rises in food prices could make nutritious foods less affordable, particularly animal-source foods, which are rich in micronutrients. This situation may lead to worse nutritional outcomes for lower-income households [35]. The data also shed light on other relevant socioeconomic variables. There was a decline in the proportion of households who sold livestock, which could have implications for household income and food security. A small increase in the proportion of crops sold was observed, which could suggest the possibility of some changes in agricultural practices or market dynamics over the periods. Household per capita income also saw a slight decrease, indicating potential economic challenges for the households in meeting their needs. The dependency ratio increased significantly, pointing to larger family sizes or more dependents per working adult, which could strain household resources.

As expected, the average age of children in the sample increased as well as the average age of the heads of household. Households headed by female have also increased. These demographic shifts could have social and economic implications, including changes in household decision-making dynamics. The proportion of women with decision-making power over income shows a significant decrease, potentially reflecting gender disparities in economic empowerment. Overall, the data show temporal changes in our variables, revealing dynamic shifts in child nutrition, food prices, and socioeconomic factors, which highlight the

Table 1
Summary statistics of variables with mean differences between 2013 and 2016.

Variable	Pooled sample				2013	2016	Mean difference
	Mean	Std. Dev.	Min	Max	Mean	Mean	
Child nutritional outcomes							
Stunting	0.35	0.48	0	1	0.34	0.36	0.02
Height-for-Age z-scores	−0.97	2.19	−7.71	6.88	−0.68	−1.26	−0.58***
Wasting	0.10	0.30	0	1	0.13	0.07	−0.06***
Weight-for-Height z-scores	−0.08	1.71	−6.71	6.78	−0.29	0.12	0.41***
Underweight	0.16	0.36	0	1	0.18	0.14	−0.04*
Weight-for-Age z-scores	−0.55	1.56	−6.21	6.53	−0.57	−0.53	0.05
Food price variables							
Sorghum price	100.12	38.46	51.47	289.48	93.39	106.86	13.47***
Maize price	91.18	33.96	45.44	261.57	88.47	93.90	5.43***
Bread price	935.53	114.55	683.86	1200.00	879.33	991.73	112.4***
Rice price	190.08	46.17	84.66	343.51	170.36	209.80	39.44***
Garri price	133.62	35.72	76.48	453.93	125.66	141.59	15.93***
Yam price	135.84	40.52	44.61	314.11	130.12	141.56	11.44***
Beans price	234.82	50.39	138.60	362.50	243.47	226.17	−17.3***
Milk price	113.07	13.62	86.67	208.33	102.77	123.37	20.6***
Beef price	187.39	52.88	50.00	350.00	158.19	216.59	58.4***
Egg price	348.90	30.07	294.67	440.00	350.29	347.51	−2.78***
Fish price	1562.93	421.64	906.35	7128.47	1344.18	1781.68	437.5***
Cooking oil price	307.01	43.52	193.33	406.22	283.02	331.00	47.98***
Sugar price	244.65	32.16	161.43	382.75	224.31	264.99	40.68***
Other control variables							
Household sold livestock	0.26	0.44	0	1	0.28	0.24	−0.04*
Proportion of crop sold	0.24	0.28	0	1	0.22	0.25	0.03*
Women decide on household income score	0.19	0.14	0	0.60	0.23	0.15	−0.08***
Adjusted Household per capita income (Naira*10,000)	0.05	0.09	0.01	1.70	0.06	0.04	−0.02***
Dependency ratio	2.81	1.26	0.00	10.00	2.70	2.92	0.22***
Female headed household	0.05	0.22	0	1	0.04	0.06	0.02***
Age of household head in year	45.19	11.09	19.00	100.00	43.81	46.56	2.75***
Age in month	30.10	18.81	0.03	59.89	12.64	47.56	34.92**
Child is girl	0.47	0.50	0	1			
North-Central (Base)	0.16	0.37	0	1			
North-East	0.25	0.43	0	1			
Nort-West	0.32	0.46	0	1			
South-East	0.16	0.36	0	1			
South-South	0.09	0.28	0	1			
South-West	0.03	0.17	0	1			

*** $p < 0.01$ represents significance at 1 % level. Mean differences based on Paired Sample t-Test.

complex challenges in enhancing child nutrition. We provide the correlations among food prices at a given time period in Table A1 in the Appendix.

5.2. Regression results of the determinants of children undernutrition

The regression results of the effects of food price and other determinants on child undernutrition are presented in Tables 2, 3, and 4 based on correlated random-effects (CRE) probit models and the fixed-effects models. The Wald Chi-square statistics of the CRE models are statistically significant ($p<0.05$), implying that the CRE models can be relied upon to explain the relationships between the likelihood of child undernutrition and the identified influencers. The relevant portion of the results, which captures the within effects of the time-varying variables, are presented to save space. A fuller version of the results is presented in Tables S2 to S4 in the online supplementary material.

5.2.1. Effects of food price changes and other determinants on child stunting

The results of factors influencing the likelihood of child stunting and those associated with HAZ of child are presented in Table 2. We discussed the average partial effects using the CRE probit model. Stunting is significantly influenced by various factors. Specifically, the results show that a 1 Naira rise in the price of rice, beef, eggs, fish, and cooking oil over time is significantly associated with an increase in the probability of a child experiencing stunting by 0.0018, 0.0017, 0.0021, 0.0002, and 0.0016 points, respectively. Put in another way, a 100 Naira increase in the price of each mentioned food items is expected to raise the probability of stunting by 0.18, 0.17, 0.21, 0.02, and 0.16 points, respectively. Consistent with these findings, Brenton and Nyawo [36] found a positive association between higher cereals prices and increased prevalence of child stunting in children under five years old. Headey and Ruel [21] also found that food inflation increased the risk of stunting in children aged 2–5 years. Evidence suggests that the high cost of animal proteins leads to reduced consumption among low-income households, which in turn increases the prevalence of stunting [35].

The results from the fixed-effect linear model are comparable and show that HAZ in children reduces by 0.0066, 0.0101, 0.0013 and 0.0095 points, respectively, with a rise in the price of rice, beef, fish, and cooking oil. However, a 1 Naira rise in maize price decreases the probability of stunting in children by 0.012 points. This might be because higher maize prices translate to better economic conditions for the households, or they shift their dietary patterns to less expensive foods that favor improved child growth. Nonetheless, it should be noted that except the households are supported to sufficiently raise farm productivity, food price escalation may continue for a long time, and if not addressed could elevate the prevalence of child stunting. Curtailing price surge would also entail curtailing post-harvest losses, investing in low-cost processing technologies and infrastructure that will lower the cost of foods, among others.

Higher household per capita income over time significantly reduced the probability of child stunting. This suggests that the pathway of

Table 2
Regression results of the effects of food price changes on child stunting.

	Height-for-Age z-scores < −2 SD (Stunting)				Height-for-Age z-scores	
	CRE Pooled Probit Model		Marginal Effect of the CRE Pooled Probit Model		Fixed-Effects Linear Model	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Sorghum price	0.0051	0.0052	0.0017	0.0017	−0.0087	0.0054
Maize price	−0.0129**	0.0065	−0.0043**	0.0022	−0.0017	0.0067
Bread price	0.0012	0.0008	0.0004	0.0003	−0.0015	0.0012
Rice price	0.0053***	0.0019	0.0018***	0.0006	−0.0066**	0.0029
Garri price	−0.0006	0.0029	−0.0002	0.0010	0.0004	0.0034
Yam price	−0.0008	0.0015	−0.0003	0.0005	−0.0025	0.0024
Beans price	0.000013	0.0022	0.000004	0.0007	−0.0002	0.0031
Milk price	−0.0056	0.0084	−0.0019	0.0028	−0.0029	0.0096
Beef price	0.0052***	0.0018	0.0017***	0.0006	−0.0101***	0.0025
Egg price	0.0063**	0.0029	0.0021**	0.0010	−0.0037	0.0047
Fish price	0.0007***	0.0002	0.0002***	0.00008	−0.0013***	0.0003
Cooking oil price	0.0047**	0.0020	0.0016**	0.0007	−0.0095***	0.0032
Sugar price	−0.0021	0.0030	−0.0007	0.0010	−0.0053	0.0048
Household sold livestock	−0.1347	0.1593	−0.0451	0.0533	0.0347	0.2476
Proportion of crop sold	0.4733*	0.2846	0.1586*	0.0947	−1.7687***	0.4754
Women decide on income	−0.6980	0.6764	−0.2339	0.2264	0.7100	1.0384
Household per capita income	−1.5789**	0.6691	−0.5291**	0.2230	2.3653	1.6546
Dependency ratio	0.1437*	0.0750	0.0482*	0.0251	−0.0908	0.1207
Age of household head	−0.0218	0.0192	−0.0073	0.0064	0.0216	0.0310
Age of child in year	0.0023	0.0110	0.0008	0.0037	−0.0240	0.0312
Female headed household	−0.3705	0.5285	−0.1242	0.1772	0.8559	0.7537
Child is girl	0.0355	0.0916	0.0119	0.0307		
Constant	−3.5888**	1.7642			11.4316***	3.1630
Wald chi2	112.8400					
Prob > chi2	0.0000					
Pseudo R-Squared	0.0872					
Log pseudolikelihood	−571.2786					
Sigma(e)					1.9094	
Sigma(u)					2.0104	
Rho					0.4743	
corr(ui, Xb)					−0.4827	
Prob > *F*					0.0000	
F(22, 484)					4.6800	
Number of observations	970		970		970	

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$ represent significance at 1 %, 5 % and 10 % level respectively.
Note: Survey year and regional dummies were controlled for in the CRE pooled probit model.

Table 3
Regression results of the effects of food price changes on child wasting.

	Weight-for-Height z-scores <−2 SD (Wasting)				Weight-for-Height z-scores	
	CRE Pooled Probit Model		Marginal Effect of the CRE Pooled Probit Model		Fixed-Effects Linear Model	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Sorghum price	−0.0072	0.0052	−0.0011	0.0008	0.0032	0.0039
Maize price	0.0122**	0.0056	0.0019**	0.0009	−0.0161**	0.0043
Bread price	0.0015	0.0011	0.0002	0.0002	0.0006	0.0009
Rice price	−0.0013	0.0029	−0.0002	0.0004	0.0017	0.0023
Garri price	0.0071*	0.0041	0.0011*	0.0006	0.0005	0.0033
Yam price	−0.0047**	0.0022	−0.0007**	0.0003	0.0023	0.0026
Beans price	−0.0012	0.0027	−0.0002	0.0004	0.0060**	0.0028
Milk price	0.0093	0.0094	0.0014	0.0014	−0.0067	0.0073
Beef price	−0.0040*	0.0021	−0.0006*	0.0003	0.0008	0.0019
Egg price	−0.0039	0.0051	−0.0006	0.0008	0.0006	0.0038
Fish price	−0.0001	0.0003	0.000010	0.0001	−0.0001	0.0002
Cooking oil price	0.0019	0.0026	0.0003	0.0004	−0.0044*	0.0024
Sugar price	−0.0022	0.0039	−0.0003	0.0006	−0.0011	0.0036
Household sold livestock	0.0391	0.2191	0.0060	0.0335	−0.0569	0.1885
Proportion of crop sold	0.4466	0.4062	0.0682	0.0621	−0.3772	0.3293
Women decide on income	−0.9645	0.9374	−0.1474	0.1434	0.2370	0.8498
Household per capita income	−4.8480*	2.5480	−0.7408*	0.3885	0.0057	0.7977
Dependency ratio	0.0120	0.1140	0.0018	0.0174	−0.0725	0.1013
Age of household head	0.0425*	0.0252	0.0065*	0.0039	−0.0143	0.0176
Age of child in year	−0.0031	0.0139	−0.0005	0.0021	−0.0119	0.0195
Female headed household	0.2505	1.0623	0.0383	0.1624	−0.4790	0.9672
Child is girl	−0.1102	0.1212	−0.0168	0.0186		
Constant	2.8283	2.7119			1.2098	2.4154
Wald chi2	103.9500					
Prob > chi2	0.0000					
Pseudo R-Squared	0.1331					
Log pseudolikelihood	−273.3561					
Sigma(e)					1.3567	
Sigma(u)					1.5430	
rho					0.4360	
corr(ui, Xb)					−0.2444	
Prob > *F*					0.0008	
F(22, 484)					2.350	
Number of observations	970		970		970	

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$ represent significance at 1 %, 5 % and 10 % level respectively.
Note: Survey year and regional dummies were controlled for in the CRE pooled probit model.

overall income growth, including sales of livestock and crops such as maize, is critical for child nutrition improvements, contributing to a reduction in stunting. This finding aligns with Biadgilign et al. [37], who established that income growth substantially reduced child stunting in Ethiopia. Results further show that an increase in the proportion of crops sold increased the probability of being stunted in children. This is contrary to expectation and several reasons may be responsible. First, it might be that the income gained from crop sales is not adequately spent on nutritious food, possibly because of some pressing non-food related financial obligations that must be met at a certain time. Second, households may sometimes sell a diverse range of nutritious crops that can result in their food baskets lacking a variety of food with essential nutrients for children's growth. At the same time, increased reliance on the market for food also exposes the household to price fluctuations.

Our findings suggest that for food price policy to be more nutrition-sensitive and advance nutrition outcomes, it must curtail extreme rises in the price of rice and animal proteins. Also, the policy should furnish farm households with information on strategies for income improvement, including which specific crops to increase sales and the timing of sales, to advance nutritional wellbeing of members.

Selling livestock does not contribute significantly to the reduction of child stunting. This could mean losing the direct sources of animal proteins (such as milk, meat, or eggs) which could have played a role in improving children's diets through self-consumption. This may be so especially if households spent the income from livestock sales on other obligations that do not substantially improve nutrition. This aspect is important for policymakers, underscoring the importance of designing targeted nutritional programmes and health educational initiatives in agricultural communities. This is because studies have established an association between increased consumption of animal-sourced foods and reduced prevalence of wasting in under-five children [38].

5.2.2. *Effects of food price changes and other determinants on child wasting*

Table 3 shows the results of the factors associated with the likelihood of child wasting and those influencing child's WHZ. There is an association between increased prices of maize and garri and wasting in children. Specifically, a unit change (rise) in the price of maize and garri over time significantly increases the probability of child wasting by 0.0122 and 0.0071 points, respectively. This implies that as the cost of staples increases, so does wasting. Efforts to calm extreme hikes in the prices of maize and garri becomes crucial for wasting reduction.

In a consistent fashion, the fixed effects result also shows that a one-unit rise in maize price over time increased WHZ by 0.0161 points. Maize and garri are also important staples widely consumed in Nigeria, and their consumption may not significantly change even with a marginal price increase. Therefore, making these foods more affordable can substantially improve children's nutritional outcomes by ensuring households consistently meet their calorie intake, which is crucial for preventing conditions like wasting. Findings are in line with Headey and Ruel [21], who found significant influence of high shocks in food prices on prevalence of child wasting. In contrast, higher prices for yam are linked to a decreased prevalence of wasting. It might be that households

Table 4
Regression results of the effects of food price changes on child underweight.

	Weight-for-Age z-scores <−2 SD (Underweight)				Weight-for-Age z-scores	
	CRE Pooled Probit Model		Marginal Effect of the CRE Pooled Probit Model		Fixed-Effects Linear Model	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
Sorghum price	0.0008	0.0042	0.0002	0.0009	0.0001	0.0036
Maize price	0.0092*	0.0052	0.0020*	0.0011	−0.0158***	0.0045
Bread price	0.0006	0.0009	0.0001	0.0002	−0.0002	0.0008
Rice price	0.0059**	0.0024	0.0013**	0.0005	−0.0030	0.0023
Garri price	−0.0062	0.0039	−0.0013	0.0008	0.0004	0.0020
Yam price	−0.0075***	0.0019	−0.0016***	0.0004	0.0003	0.0018
Beans price	−0.0042*	0.0024	−0.0009*	0.0005	0.0031	0.0023
Milk price	0.0151*	0.0082	0.0032*	0.0018	0.0002	0.0063
Beef price	−0.0022	0.0019	−0.0005	0.0004	−0.0032*	0.0018
Egg price	0.0026	0.0034	0.0006	0.0007	−0.0008	0.0030
Fish price	−0.0002	0.0003	−0.0000486	0.0001	−0.0009***	0.0002
Cooking oil price	0.0009	0.0027	0.0002	0.0006	−0.0136***	0.0023
Sugar price	−0.0100**	0.0037	−0.0021**	0.0008	−0.0036	0.0037
Household sold livestock	−0.1253	0.1954	−0.0269	0.0420	0.0300	0.1779
Proportion of crop sold	0.6014**	0.3049	0.1292**	0.0653	−1.1342***	0.2994
Women decide on income	−1.4960*	0.7893	−0.3215*	0.1699	0.9807	0.6838
Household per capita income	−0.9127	0.5722	−0.1961	0.1226	1.7925**	0.8179
Dependency ratio	0.2959***	0.0966	0.0636***	0.0208	−0.0875	0.0853
Age of household head	−0.0188	0.0196	−0.0040	0.0042	−0.0026	0.0222
Age of child in month	−0.0053	0.0124	−0.0011	0.0027	−0.0316*	0.0175
Female headed household	−0.6436	0.7319	−0.1383	0.1575	0.0899	0.6580
Child is girl	0.0548	0.1068	0.0118	0.0229		
Constant	−6.4344	2.0100			7.9698	2.1656
Wald chi2	115.6800					
Prob > chi2	0.0000					
Pseudo R-Squared	0.1055					
Log pseudolikelihood	−378.1908					
Sigma(e)					1.3482	
Sigma(u)					1.3930	
rho					0.4836	
corr(ui, Xb)					−0.4745	
Prob > *F*					0.0000	
F(22, 484)					4.7700	
Number of observations	970		970		970	

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$ represent significance at 1 %, 5 % and 10 % level respectively.
Note: Survey year and regional dummies were controlled for in the CRE pooled probit model.

took advantage of the incentive offered by the price rise to realise extra income.

Furthermore, the results demonstrate an intricate relationship between household income and the prevalence of wasting. This further justifies the need to improve household income for better nutritional outcomes. In line with previous findings, Biadgilign et al. [37], discovered a significant inverse relationship between income growth and child wasting in Ethiopia. Vollmer et al. [39] also found a significant association between economic growth and a decrease in child wasting in LMICs. More broadly, increased income can facilitate the purchase of foods not produced by households and other essential non-food items related to nutrition [40,41].

5.2.3. Effects of food price changes and other determinants on child underweight

Being underweight in children is a sign of overall undernutrition, and our results (Table 4) show that it is influenced by a combination of food prices and socioeconomic factors. The positive coefficients for maize price, rice price, and milk price indicate that higher prices for these foods are associated with an increased prevalence of child underweight. A unit increase in the price of maize, rice, and milk over time increases the probability of child underweight by 0.0092, 0.0059 and 0.0152 points, respectively. Our findings also call for more commitments to enhancing productivity in maize, rice, and milk (dairy) production, as a critical step in reducing multiple forms of childhood malnutrition

Increased prices of beans and yam significantly reduced the rate of child underweight. Even though higher prices of beans and yam could signal an incentive for improved nutrition for the farm households, their prices should be sensitively guided, and monitored to avoid substantial negative net impacts on the entire population. This is because beans and yam are also among the widely consumed staples, belonging to the major categories of foods consumed in Nigeria [42]. Generally, an increased price of sugar is unlikely to elevate child underweight. In line with findings on stunting, results show that an increase in the proportion of crops sold increased the probability of being underweight in children. The negative and statistically significant coefficient of women's decision-making power over income also highlights the role of women empowerment in enhancing nutrition and health outcomes.

6. Conclusion and recommendations

An understanding of how food prices interact to shape children's nutrition outcomes is vital for formulating nutrition-sensitive, food-price-related agricultural policies to improve the nutritional outcomes of children in Africa. Nigeria needs such a price policy, especially given the historical experiences of food price hikes, with possible upward future trends. Empirical studies examining the effects of food prices on nutrition outcomes are therefore critical for policy design. Consequently, this study focuses mainly on the nexus between food price changes and nutrition outcomes, while also accounting for the role that income, and women's decision making, and empowerment could play in the evolution of stronger and more coherent policy pathways for better nutrition outcomes in Nigeria.

Using nationally representative agricultural household data, we found that between 2013 and 2016, the prevalence of stunting in children increased, while wasting and underweight decreased. There was a significant rise in the prices of staples and animal-source food items across the year, with effects of their changes observed on different dimensions of children's nutritional outcomes. Particularly, price increases in rice, fish, eggs, beef, and cooking oil have increased stunting risks, whereas an increase in maize price reduced them. Children's wasting risk heightened with increases in the prices of maize and garri but declined with those of yam and beef. Rises in the prices of maize, rice, and milk increased the likelihood of children being underweight, while those of beans, yam and sugar diminished this risk. The consistent relationship between rising animal protein prices and the reduced child growth also underscores the importance of tackling political violence that disrupts livestock supply chains, affecting food availability and triggering elevated food prices and reduced food consumption among many households in the country [43,44].

We advocate for agriculture-led, nutrition-sensitive food price policies that address the rising costs of animal proteins, such as fish, eggs, milk, beef, and key staples like rice, garri, and maize. These policies should also sensitively monitor and regulate the prices of cooking oil, yam, and beans to enhance nutritional outcomes in the country. Our study highlights important policy and program implications, including the need for strategic grain reserves and buffer operations for staples such as rice and maize, reducing post-harvest losses, and investing in processing technologies for major staples, including rice, maize, yam, and garri. This should also include a well-crafted minimum support price on farm outputs, taxes along marketing chains, and farm-level input interventions to raise productivity of key staple crops, fish, and livestock. There are also implications for actions that can influence domestic food availability (supply). There should be some level of restriction on the volume of imported cooking oils while boosting and repositioning the country's oil palm sector for global competitiveness. The rising cost of rice also has implications for consumer-oriented subsidies on rice, especially for the poorest household groups, among others.

CRediT authorship contribution statement

Dare Akerele: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Olusegun Fadare:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Adebayo Ogunniyi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis. **Olutayo Adeyemi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis. **Mistura Rufai:** Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis.

Declaration of competing interest

None.

Acknowledgements

This work was carried out as part of the collaborative research project under the Agriculture and Food Policy Analysis for Nutrition Outcomes in Africa (AFPON) Project. It was supported by the African Economic Research Consortium (AERC) based in Nairobi, Kenya and the Bill & Melinda Gates Foundation under grant number RC18524. The supporting institutions provided the trainings that enhanced authors' capacities in the study design, data analysis and interpretation and in the writing of the report. We would like to thank the Executive Director of AERC, Professor Njuguna Ndung'u, the project coordinator, Professor David Sahn (University of Cornell), and Dr Esi Colecraft (University of Ghana) and the AERC (AFPON) Projec Team for their invaluable support and comments that culmulated in the article publication. The seminar participants at the proposal, mid-review and final report workshops organized by AERC are also appreciated for providing helpful comments and suggestions.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wds.2024.100158.

Appendix

Table A1
Correlations of the food price changes in a given time period.

Variables	Sorghum price	Maize price	Bread price	Rice price	Garri price	Milk price	Beef price	Egg price	Sugar price	Beans price	Yam price	Fish price	Cooking oil price
Post-harvest 2013													
Sorghum price	1.000												
Maize price	0.8364*	1.0000											
Bread price	0.1388*	0.2456*	1.0000										
Rice price	0.3865*	0.2979*	0.0254	1.0000									
Garri price	0.5224*	0.3152*	−0.1766*	0.3158*	1.0000								
Milk price	0.2740*	0.1479*	0.0821	0.2181*	0.1267*	1.0000							
Beef price	0.3673*	0.4554*	0.0921*	0.1367*	0.3290*	0.0966*	1.0000						
Egg price	−0.0208	0.0138	0.2026*	−0.1373*	−0.1593*	0.1274*	−0.0640	1.0000					
Sugar price	−0.0766	−0.1967*	−0.2526*	−0.0378	−0.1321*	−0.0124	−0.5400*	−0.0586	1.0000				
Beans price	0.5504*	0.4422*	0.2602*	0.2131*	0.2060*	0.5330*	0.1774*	0.2106*	−0.0265	1.0000			
Yam price	−0.0660	−0.1077*	0.2291*	0.0391	0.0338	0.0722	−0.0790	0.1011*	−0.1355*	−0.1096*	1.0000		

(*continued on next page*)

Table A1 (*continued*)

Variables	Sorghum price	Maize price	Bread price	Rice price	Garri price	Milk price	Beef price	Egg price	Sugar price	Beans price	Yam price	Fish price	Cooking oil price
Fish price	0.3304*	0.2943*	0.0419	0.2891*	0.0390	0.2499*	−0.0731	−0.1520*	−0.1329*	0.1232*	0.1518*	1.0000	
Cooking oil price	0.1877*	0.0911*	−0.0555	−0.0138	0.0717	0.0048	−0.0277	0.2644*	0.2981*	−0.0253	−0.3443*	−0.0776	1.0000
Post-harvest 2016													
Sorghum price	1.000												
Maize price	0.9166*	1.000											
Bread price	0.4742*	0.3955*	1.000										
Rice price	0.4729*	0.4139*	0.1769*	1.000									
Garri price	0.0769	0.0959*	−0.1567*	0.0969*	1.000								
Milk price	0.0239	0.1516*	−0.2161*	−0.2067*	0.0297	1.000							
Beef price	0.0078	0.0653	0.1616*	0.1394*	−0.1694*	−0.1992*	1.000						
Egg price	0.0899*	0.1613*	0.2043*	−0.0073	−0.0705	−0.1917*	0.2393*	1.000					
Sugar price	−0.0961*	−0.1676*	−0.026	0.0052	−0.052	0.1678*	−0.0057	−0.2367*	1.000				
Beans price	0.7686*	0.7237*	0.2890*	0.3731*	−0.0287	−0.0397	0.1399*	0.0589	−0.1657*	1.000			
Yam price	0.2169*	0.2210*	0.1596*	0.1326*	0.3123*	0.0758	0.1111*	0.0975*	−0.2466*	0.0917*	1.000		
Fish price	0.2323*	0.1176*	0.3834*	0.0007	−0.1004*	−0.1886*	0.0948*	0.0996*	0.0386	0.2009*	−0.0491	1.000	
Cooking oil price	0.0349	0.1653*	−0.1634*	−0.045	0.0006	0.1391*	−0.1756*	−0.1399*	−0.0684	−0.1256*	−0.0113	−0.3379*	1.000

* Correction coefficients are statistically significant at 5 %.

References

[1] UNICEF/WHO/World Bank (2023). Joint child malnutrition estimates (jme) — levels and trends –2023 edition. https://data.unicef.org/resources/jme-report-2023/.

[2] T. Belachew, C. Hadley, D. Lindstrom, A. Gebremariam, C. Lachat, P. Kolsteren, Food insecurity, school absenteeism and educational attainment of adolescents in Jimma Zone Southwest Ethiopia: a longitudinal study, Nutr. J. 10 (2011) (2011) 1–9, https://doi.org/10.1186/1475-2891-10-29.

[3] International Food Policy Research Institute, Global nutrition report 2015: actions and accountability to advance nutrition and sustainable development, International Food Policy Research Institute, Washington, D.C., 2015, https://doi.org/10.2499/9780896298835.

[4] Federal Ministry of Agriculture and Rural Development, Nigerian agricultural sector food security and nutrition strategy 2016–2025, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria, 2017.

[5] Central Bank of Nigeria, 2012 Statistical bulletin: domestic production, consumption and prices. At http://www.cenbank.org/documents/Statbulletin.asp Accessed 20 June 2018.

[6] Central Bank of Nigeria, 2016 Statistical bulletin: domestic production, consumption and prices. At http://www.cbn.gov.ng/documents/Statbulletin.asp Accessed 20 June 2018.

[7] Central Bank of Nigeria, 2018 Annual statistical bulletin: domestic production, consumption and prices. At https://www.cbn.gov.ng/documents/Statbulletin.asp Accessed 20 June 2018.

[8] Central Bank of Nigeria, 2022 Statistical bulletin: domestic production, consumption and prices. At http://www.cenbank.org/documents/Statbulletin.asp. Accessed 12 December 2023.

[9] National Bureau of Statistics and United Nations Children's Fund, Multiple indicator cluster survey 2016–17, survey findings report. National Bureau of Statistics and United Nations Children's Fund. Abuja, Nigeria. At https://www.unicef.org/nigeria/reports/multiple-indicator-cluster-survey-2016-17-mics. Accessed 12 April 2018.

[10] C. Arndt, M.A. Hussain, V. Salvucci, L.P. Østerdal, Effects of food price shocks on child malnutrition: the Mozambican experience 2008/2009, Econ. Hum. Biol. 22 (2016) 1–13, https://doi.org/10.1016/j.ehb.2016.03.003.

[11] A.M. Shittu, O.A. Obayelu, K.K. Salman, Welfare effects of policy-induced rising food prices on farm households in Nigeria. 2015, https://www.ifpri.org/publication/welfare-effects-policy-induced-rising-food-prices-farm-households-nigeria.

[12] O. Fadare, G. Mavrotas, D. Akerele, M. Oyeyemi, Micronutrient-rich food consumption, intra-household food allocation and child stunting in rural Nigeria, Public Health Nutr. 22 (3) (2019) 444–454.

[13] O.A. Otekunrin, O.A. Otekunrin, Nutrition outcomes of under-five children of smallholder farm households: do higher commercialization levels lead to better nutritional status? Child Indic. Res. 15 (6) (2022) 2309–2334, https://doi.org/10.1007/s12187-022-09960-2.

[14] USAID (United States Agency for International Development), Nigeria: Nutrition Profile, 2021. Updated May 2021. At, https://www.usaid.gov/sites/default/files/2022-05/Copy_of_tagged_Nigeria-Nutrition-Profile.pdf. Accessed 12 December 2023.

[15] M. Ogunnaike, M. Kehinde, O. Olabode, Determinants of malnutrition among children in rural farm households in Ogun State, Nigeria. Fudma J. Sci. 4 (4) (2020) 90–95, https://doi.org/10.33003/fjs-2020-0404-341.

[16] O.A. Obayelu, O.R. Adeleye, Explaining child nutritional status in rural Nigeria: socioeconomic dimensions, J. Hunger. Environ. Nutr. 16 (6) (2021) 829–846, https://doi.org/10.1080/19320248.2020.1781011.

[17] A. Shittu, D. Akerele M. Haile, Effects of food price spikes on household welfare in Nigeria, University of Bonn, Center for Development Research (ZEF) Discussion Papers on Development Policy, 2018. Paper No. 248.

[18] C.P. Adekunle, S.O. Akinbode, A.M. Shittu, S. Momoh, Food price changes and farm households' welfare in Nigeria: direct and indirect approach, J. Appl. Econ. 23 (1) (2020) 409–425, https://doi.org/10.1080/15140326.2020.1743103.

[19] D.T. Fajobi, J.O. Ajetomobi, M.O. Raufu, M.O. Fajobi, P. Paramasivam, Effects of food price on nutrition outcomes among women in Nigeria, Food Sci. Nutr. (2023), https://doi.org/10.1002/fsn3.3737.

[20] Central Bank of Nigeria, 2017 Annual statistical bulletin- domestic production, consumption and prices https://www.cbn.gov.ng/documents/Statbulletin.asp. Accessed 20 June 2018.

[21] D. Headey, M. Ruel, Food inflation and child undernutrition in low- and middle-income countries, Nat. Commun. 14 (1) (2023) 5761, https://doi.org/10.1038/s41467-023-41543-9.

[22] A.E. Obayelu, Global food price increases and nutritional status of Nigerians: the determinants, coping strategies, policy responses and implications, ARPN J. Agric. Biol. Sci. 5 (2) (2010) 67–80.

[23] A.S. Olomola, The political economy of food price policy in Nigeria". WIDER Working Paper No. 2013/016. (2013). The United Nations University World Institute for Development Economic Research (UNU-WIDER), Helsinki.

[24] O. Ayinde, Is marketing board a barrier or a stimulant of agricultural production in West Africa? A comparative study of Ghana and Nigeria cocoa pricing eras, Ghana J. Develop. Stud. 11 (2) (2014) 50–66.

[25] A.D. Dangour, S. Hawkesworth, B. Shankar, L. Watson, C.S. Srinivasan, E. H. Morgan, J. Waage, Can nutrition be promoted through agriculture-led food price policies? A systematic review, BMJ Open. 3 (6) (2013) e002937, https://doi.org/10.1136/bmjopen-2013-002937.

[26] S. Gillespie, J. Harris, S. Kadiyala, The Agriculture-Nutrition Disconnect in India: What Do We Know? IFPRI Discussion Paper No. 1187, International Food Policy Research Institute, Washington, D.C, 2012.

[27] NBS. 2016. Nigeria national bureau of statistics. general household survey, panel (GHS-Panel) 2015-2016. Ref. NGA_2015_GHSP-W3_v02_M. Dataset downloaded from www.microdata.worldbank.org on June 5, 2020.

[28] WHO Multicentre Growth Reference Study Group, WHO child growth standards based on length/height, weight and age, Acta Paediatr. 95 (S450) (2006) 76–85.

[29] M. De Onis, WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age, World Health Organization, Geneva, Switzerland, 2006, p. 2006.

[30] J.M. Wooldridge, 3013a. Correlated random effects panel data models. May 13-19, 2013. Bonn, Germany: IZA Summer School in Labor Economics. At https://conference.iza.org/conference_files/SUMS_2013/slides_2_nonlin_iza.pdf. Accessed 12 April 2018.

[31] J.M. Wooldridge, 2013b. Introduction and linear models-correlated random effects panel data models. https://conference.iza.org/conference_files/SUMS_2013/slides_1_linear_iza.pdf.

[32] B.G. Bedane, AERC Working Paper BMGF-002, 2020.

[33] National Population Commission (NPC) Nigeria and ICF International, Nigeria demographic and health survey 2013, NPC and ICF International, Abuja, Nigeria, and Rockville, Maryland, USA, 2014. At, https://www.unicef.org/nigeria/sites/unicef.org.nigeria/files/2018-09/Nigeria-demographic-and-health-survey-2013.pdf. Accessed 22 April 2018.

[34] UNICEF (the United Nations Children's Fund), National nutrition and health survey (NNHS) 2015, NBS, UNICEF, 2015. At, https://www.unicef.org/nigeria/media/1521/file/Nigeria-national-nutrition-and-health-survey-2015.pdf.pdf. Accessed 12 April 2018.

[35] D. Headey, K. Hirvonen, J. Hoddinott, Animal sourced foods and child stunting, Am. J. Agric. Econ. 100 (5) (2018) 1302–1319, https://doi.org/10.1093/ajae/aay053.
[36] P. Brenton, M. Nyawo, Cereal prices and child undernutrition in Ethiopia, J. Dev. Stud. 57 (12) (2021) 2045–2062, https://doi.org/10.1080/00220388.2021.1939862.
[37] S. Biadgilign, A. Shumetie, H. Yesigat, Does economic growth reduce childhood undernutrition in Ethiopia? PLoS. One 11 (8) (2016) e0160050 https://doi.org/10.1371/journal.pone.0160050.
[38] Z. Ali, M. Saaka, A.G. Adams, S.K. Kamwininaang, A.R. Abizari, The effect of maternal and child factors on stunting, wasting and underweight among preschool children in Northern Ghana, BMC. Nutr. 3 (2017) 1–13, https://doi.org/10.1186/s40795-017-0154-2.
[39] S. Vollmer, C. Bommer, A. Krishna, K. Harttgen, S.V. Subramanian, The association of parental education with childhood undernutrition in low- and middle-income countries: comparing the role of paternal and maternal education, Int. J. Epidemiol. 46 (1) (2017) 312–323, https://doi.org/10.1093/ije/dyw133.
[40] M.G. Ahamad, R.K. Khondker, Z.U. Ahmed, F. Tanin, Seasonal food insecurity in Bangladesh: evidences from northern areas, Mitig. Adapt. Strateg. Glob. Change. 18 (2013) 1077–1088, https://doi.org/10.1007/s11027-012-9408-0.
[41] D.O. Omondi, P. Kirabira, Socio-demographic factors influencing nutritional status of children (6–59 months) in Obunga slums, Kisumu City, Kenya, Public Health Res 6 (2) (2016) 69–75, https://doi.org/10.5923/j.phr.20160602.07.
[42] National Bureau of Statistics, Consumption expenditure pattern in Nigeria, 2024. https://www.nigerianstat.gov.ng/pdfuploads/Consumption%20Expenditure%20Pattern%20in%20Nigeria%202019.pdf. Accessed 14th March 2024.
[43] O. Fadare, C. Srinivasan, G. Zanello, Livestock diversification mitigates the impact of farmer-herder conflicts on animal-source foods consumption in Nigeria, Food Policy. 122 (2024) 102586.
[44] M. Musab, A. A. Otovwe, Impact of Boko Haram insurgency on the Nutritional status of two communities in Gulani Local Government Area, Yobe State, Nigeria, Global J. Pure Appl. Sci. 27 (2021) 367–374.