food & nutrition research

ORIGINAL ARTICLE

Nutrition education, farm production diversity, and commercialization on household and individual dietary diversity in Zimbabwe

Conrad Murendo[1]*, Brighton Nhau[2], Kizito Mazvimavi[1], Thamsanqa Khanye[3] and Simon Gwara[1]

[1]International Crops Research Institute for the Semi-Arid Tropics, Bulawayo, Zimbabwe; [2]United Nations, Food and Agriculture Organization, Harare, Zimbabwe; [3]Community Technology Development Organization, Harare, Zimbabwe

Abstract

Background: Nutrition education is crucial for improved nutrition outcomes. However, there are no studies to the best of our knowledge that have jointly analysed the roles of nutrition education, farm production diversity and commercialization on household, women and child dietary diversity.
Objective: This article jointly analyses the role of nutrition education, farm production diversity and commercialization on household, women and children dietary diversity in Zimbabwe. In addition, we analyze separately the roles of crop and livestock diversity and individual agricultural practices on dietary diversity.
Design: Data were collected from 2,815 households randomly selected in eight districts. Negative binomial regression was used for model estimations.
Results: Nutrition education increased household, women, and child dietary diversity by 3, 9 and 24%, respectively. Farm production diversity had a strong and positive association with household and women dietary diversity. Crop diversification led to a 4 and 5% increase in household and women dietary diversity, respectively. Furthermore, livestock diversification and market participation were positively associated with household, women, and children dietary diversity. The cultivation of pulses and fruits increased household, women, and children dietary diversity. Vegetable production and goat rearing increased household and women dietary diversity.
Conclusion: Nutrition education and improving access to markets are promising strategies to improve dietary diversity at both household and individual level. Results demonstrate the value of promoting nutrition education; farm production diversity; small livestock; pulses, vegetables and fruits; crop-livestock integration; and market access for improved nutrition.

Keywords: *nutrition education*; *production diversity*; *commercialization*; *dietary diversity*; *Zimbabwe*

Received: 06 January 2018; Revised: 17 April 2018; Accepted: 19 April 2018; Published: 17 May 2018

The topics on behavior change communication (BCC), farm production diversity, and commercialization within the nutrition debate are gathering enormous interest among researchers, policy makers, and development practitioners. BCC interventions (e.g. promoting consumption of iron-rich foods, hygiene, preservation, and nutrition gardens) seek to improve household and individual nutrition knowledge and encourage behavior change adoption as well as improve decision-making on nutrition and child care as they encourage active participation of both men and women (1–4). Nutrition education increases awareness of malnutrition, benefits of consuming healthy diets, and healthy implications of consuming various foods. In Ethiopia, Hirvonen, Hoddinott, Minten and Stifel (1) found that enhanced nutrition knowledge improved children's dietary diversity only in areas with relatively good market access. Ensuring that caregivers understand what foods are appropriate for young children and women is seen as an integral component of efforts to improve maternal and children's nutritional status. Hence, BCC interventions that seek to improve caregivers' nutrition knowledge have gained popularity among policymakers in developing countries (1, 5, 6). According to Dewey and Adu-Afarwuah (6), BCC has been found to be effective at improving child-feeding practices in a number of randomized control trials in different countries. In Zimbabwe, there is poor dietary diversity as the majority of smallholder farmers heavily rely on maize, the main staple crop, which is not very nutritious. National assessments have shown that only 54% of the population consume acceptable diets and

Food & Nutrition Research 2018. © 2018 Conrad Murendo et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material for any purpose, even commercially, provided the original work is properly cited and states its license.

there is lack of protein-rich foods in the diets (7). This provides scope for promoting BCC and nutrition interventions to increase iron-rich foods and protein consumption (7).

Agriculture has a direct impact on household food security and nutrition through three pathways, which are own production, agricultural income, and women empowerment (8–10). In developing countries, agriculture through own production is the main source of diverse and nutritious foods and increased agricultural production through diversified farming can positively result in food availability, diet, and nutrition improvement (11). Agricultural income is another key pathway that can improve household food and nutrition security. Income generated from commercialization – crop and livestock sales and or income earned through farm labor supply increases household income (12). In addition, higher agricultural productivity from own production can result in improved household income through increases in marketable surplus. The improved household income might enable households to better spend their money on food and non-food items, for example, healthcare expenditure which subsequently improves nutrition, health, and welfare (9, 13–16).

Women empowerment is another important pathway to improved household nutrition. Women empowerment influences nutrition through several ways, including time use or caring capacity, workload in agriculture, maternal energy use, and women's control of income and resource allocation (9, 14). Empowered women can efficiently allocate their time for child feeding and caring, agricultural work, and household chores so as to improve household and child nutrition. It is believed that empowering women by giving them access to productive resources to the same level as men would increase yields by 20–30% and reduce the malnourished population by 100–150 million people (17). Furthermore, studies have shown that women's control of income and resources as well as greater access to markets have positive effects on household food and nutrition security as well as child education. According to literature, empowered women are better able to allocate resources for food and health care which can improve household, maternal, and child nutrition (9, 14).

There is a growing body of contrasting literature analyzing the effect of farm production diversity (8, 14, 15, 18–21), commercialization (13, 21), and nutrition knowledge (1) on household, maternal, and child nutrition. Malapit, Kadiyala, Quisumbing, Cunningham and Tyagi (14) found that production diversity positively influenced maternal and child dietary diversity in Nepal. In their study, Koppmair, Kassie and Qaim (21) conclude that farm production diversity and commercialization have a positive association with household, maternal, and child dietary diversity in Malawi. Snapp and Fisher (20) found that although crop diversity was positively associated with dietary diversity, education, income, market access, and availability of improved storage technologies had higher influence on dietary diversity. Carrleto, Corral and Guelfi (13) found little evidence of a positive relationship between commercialization and nutritional status in three countries, namely, Malawi, Tanzania, and Uganda.

The literature on agriculture–nutrition linkages has narrowly focused on farm production diversity and commercialization and only few studies have analyzed the role of nutrition education on household and individual-level nutrition (1). Furthermore, there are no studies to the best of our knowledge that have jointly analyzed the roles of nutrition education, farm production diversity, and commercialization on household, women, and child dietary diversity, especially in Zimbabwe. This is crucial given that there are context-specific factors that facilitate the functioning of impact pathways for improving nutrition (2). Furthermore, we disaggregate farm production diversity into crop and livestock diversity and analyze their separate associations together with nutrition education and commercialization on household, women, and child dietary diversity. Most studies in literature focus on nutrition outcomes at household level and fail to capture the effects at individual level (21). In addition, we investigate the association between specific crop and livestock practices on dietary diversity of household, women, and children. These areas have received little research attention. This paper attempts to fill these gaps by using cross-sectional survey data from 2,815 smallholder farm households randomly selected from eight districts in Zimbabwe.

Methodology

Data collection

The data used in this article were drawn from Crop and Livestock Production Survey conducted by Food and Agriculture Organization in 2016 as part of the annual assessment of the Livelihoods and Food Security Programme (LFSP). The programme is working to improve food security and nutrition of smallholder farmers and rural communities in eight districts of Zimbabwe (3). A total of 2,815 rural households were surveyed across eight districts (Table 1). In each district, 10 wards were purposively selected to include diversity of agricultural value chains,

Table 1. Sample

District	Household interviewed
Gokwe South	274
Guruve	391
Kwekwe	392
Makoni	306
Mt Darwin	397
Mutare	352
Mutasa	308
Shurugwi	395
Total	2,815

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276

areas with biofortified crop production, and community -based micro-finance groups. Systematic random sampling was used to select households in each ward. About 36 households were selected per ward using beneficiary lists where the sampling interval was calculated by dividing the total number of beneficiaries by 36. The enumerators visited individual households selected through this process with an allowance of not more than two house recalls after which a replacement household was found. If someone was not present at the time of the visit, the next household on the same list was chosen and not the next-door neighbor. The survey collected information on household characteristics, agricultural practices, household nutrition, maternal and child nutrition, and food security. The total number of women and children (6–23 months of age) in the 2,815 households is 2,285 and 506, respectively.

Measurements

Household dietary diversity

A modified Household Dietary Diversity Score (HDDS) (22) was calculated for each household using recall data on consumption of foods over the previous 24 h. In general, shorter recall period improves the accuracy of estimates compared with longer recall periods of 7 days (23). The food items were categorized into 12 different food groups with each food group counting toward the household score if a food item from the group was consumed by anyone in the household in the previous 24 h. The modified HDDS, then, is a count variable from 0 to 12. The food groups used to calculate the modified HDDS included cereals, roots and tubers, vegetables, fruits, meat, eggs, fish and seafood, pulses and nuts, milk and milk products, oils and fats, sugar, and condiments.

Women dietary diversity

Women dietary diversity score (WDDS) is measured using the individual dietary diversity score (22) of women aged 15–49 years. We compute individual dietary diversity scores using 24-h dietary recall data of women's own consumption from 11 food groups, namely, starchy staples; pulses; dark green leafy vegetables; vitamin A-rich fruits and vegetables; roots and tubers; other fruits and vegetables; milk and milk products; egg; fish; meat; and sugar and condiments (11, 22).

Children's dietary diversity

The child dietary diversity scores (CDDS) were used to determine the quality of the individual child's diet (14, 24). Dietary diversity of infants aged 6–23 months is measured by the number of food groups consumed in the last 24 h out of 16 food groups, namely, cereal-based foods; tubers; orange vegetables; green vegetables; orange fruits; other vegetables and fruits; juice; organ meat; meat; eggs; fish; pulses and nuts; dairy; oils; sugar; and liquids (14).

Nutrition education

Households' nutrition education is captured in the data through two questions about whether household received information on nutrition and child feeding and care. These were captured as dummy variables. Recognizing the multidimensional determinants of malnutrition in society, the LFSP project uses pluralistic extension approaches for wider dissemination of nutrition education. Various nutrition messages, for example, healthy eating, four-star diets, dietary diversification, and importance of biofortified crops are disseminated to farmers through various training platforms such as community health clubs, information and communication technology platforms (podcasts, videos, WhatsApp), and field days. These messages are disseminated by public and private extension officers, health officers, project nutritionists, trained community-based volunteers, and lead farmers (25, 26).

Farm production diversity

The number of crop and livestock species produced on a farm was used as the measure of farm production diversity (8, 18, 21). This is a simple, unweighted count measure. Second, we split and used the simple, unweighted count of only crop species produced on a farm (crop diversity) and livestock species (livestock diversity) separately. For robustness checks, we reran the model for crop and livestock diversity with a stepwise exclusion of relevant control variables in the model specifications to examine whether this influences the results significantly (27).

Commercialization

There are various definitions of commercialization (13). For the purposes of this article, we limit our definition of commercialization to two definitions: (a) household's market participation measured by the incidence of household selling crop and or livestock to the market and (b) the intensity of market participation measured by the share of crop output that the household sells to the market (13). The limitation of the first definition is its inability to measure the intensity of market participation.

Estimation strategy

To investigate the relationship between nutrition education, farm production diversification, and commercialization on dietary diversity, we estimate the following regression models:

$$DD = b_0 + b_1\text{Nutrition education} + b_2\text{Farm production diversity} + b_3\text{Commercialization} + b_4 I + b_5 H + \varepsilon \quad (1)$$

where, DD is the nutrition outcome (i.e. dietary diversity); I and H are the vectors of individual and household characteristics, respectively; b_i is the parameter to be

estimated; and ε is an error term. The parameters b_1, b_2, and b_3 capture how nutrition education, farm production diversity, and commercialization are correlated with dietary diversity, controlling for a set of observable individual and household characteristics. In the extended model specifications, we split farm production diversity into crop and livestock diversity and assess their separate roles on dietary diversity as follows:

$$DD = b_0 + b_1\text{Nutrition education} + b_2\text{Crop diversity} + b_3\text{Livestock diversity} + b_4\text{Commercialization} + b_5 I + b_6 H + \varepsilon \quad (2)$$

In Equation 2, our key parameters of interest are b_1, b_2, b_3 and b_4 which capture how nutrition education, crop and livestock diversification and commercialization are correlated with dietary diversity. A positive and significant estimate for b_1, b_2, b_3 and b_4 implies that nutrition education, crop, livestock diversity, and commercialization are associated with higher dietary diversity. The dietary diversity is a count variable that can take values between 1 and 12 (or between 1 and 9 when only including the healthier food groups) and is not normally distributed. The goodness-of-fit chi-squared tests for household (1,439, $p > 0.05$) and women dietary diversity (1,308, $p > 0.05$) were not statistically significant revealing that poisson models fit reasonably well (28). For the children dietary diversity, the goodness-of-fit chi-squared test (1,010, $p < 0.001$) is statistically significant, indicating that the data do not fit the poisson model well. Given this, the negative binomial regression which is suitable for over-dispersed data is used for estimating all the three models (28–30). Robust variance estimator is used to obtain correct standard errors for model coefficient estimates in both models (31). For both models, we compute the incident rate ratios (IRRs) and their 95% confidence intervals. The IRRs are interpreted as percent change in the expected count, thus by what percentage the dietary diversity score change when the explanatory variable changes by one unit (30, 32).

Results

Descriptive results

Table 2 describes household characteristics. The upper part of Table 2 shows dietary diversity at the household level, and individually for women and children. At the household level, mean dietary diversity is 7; that is, the average household has consumed seven food groups during the reference day. Individual-level dietary diversity is lower than those at household level. This is expected because at household level the consumption of all household members is covered, including children above the age of 5 years, adolescents, and male adults (21). About 80% of the sampled households reported to have received information on nutrition, child feeding, and care practices. BCC strategies, for example, healthy eating messages disseminated to households, women, and men through various training platforms are crucial as they increase awareness of eating balanced diets.

The average farm household produces 3.0 and 2.4 different crop and livestock species, respectively. All households grew vegetables and 67% grew pulses. In terms of market participation, 50% of the sample households were engaged in crop and/or livestock sales. About 23.3% were involved in crop sales. On the contrary, about 10% of the harvest from crops is sold. These results reveal that only a small proportion of crop produce is sold to the market. Farm households prioritize food self-sufficiency and only sell surplus to the market. The El-Nino drought of 2015/16 season resulted in poor harvest and thus reduced marketable surplus.

The bottom part of Table 2 shows the variables that we use as covariates in the different specifications of the regression models. Our sample was dominated by male-headed households (72%) with a mean age of 50.7 years. Regarding education, 53% of the household heads had secondary education and above. The household size varied from 1 to 19 members with a mean size of 5.7. Also, mean arable land size holding within the sample was found to be three hectares.

Food group consumption

As presented in Table 3, food groups that were mostly consumed by households included cereals (99%), condiments/spices/beverages (95%), oils/fats (94.3%), and sugar and sweets (84.9%). Milk and dairy products (24.4%) and eggs (22%) were the least consumed. Among households who had consumed foods from the given food groups, households' own production was the main source of vegetables (81.5%), eggs (80.5%), nuts and pulses (77.3%), and cereals (72.6%), whereas, oils and fats, sugars and sweets, condiments and spices, fish and milk products were mainly acquired through purchasing.

Table 4 shows the main food groups that were consumed by the youngest child. The food groups that were mostly consumed by the youngest child in the household included plain water (94.4%), cereals (78.7%), oils (63.9%), and cereal porridge (56.8%). Fortified baby formula (10.9%), infant formula (11.1%), orange fruits (6.5%), and other liquids (4.2%) were the least consumed. Unfortunately, we have no data on the source of foods consumed. However, the food types that young children eat are mostly acquired through purchasing rather than own production. This may suggest that young children dietary diversity is most likely influenced by income rather than farm production diversity. The results also show that approximately half of the sampled children consumed fruits and nuts.

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276

Table 2. Household, farm, and institutional sample characteristics

Variable	Description	
Household dietary diversity (mean [SD]; median)	Frequency of consumption of food groups	7.0 (2.0); 7.0
Women dietary diversity (mean [SD]; median)	Number of food groups consumed by women	4.2 (1.7); 4.0
Child dietary diversity	Number of food groups consumed by child	5.7 (3.4); 5.0
Nutrition information	Received nutrition information (1 = yes)	79
Child feeding and care	Received child feeding and care information (1 = yes)	77
Farm production diversity (mean [SD]; median)	Number of crop and livestock species reared	5.4 (1.8); 7.0
Crop diversity (mean [SD]; median)	Number of crop species grown	3.0 (1.8); 3.0
Livestock diversity (mean [SD]; median)	Number of livestock species reared	2.4 (1.2); 2.0
Beans and pulses	Grew pulses (1 = yes)	67
Vegetables	Grew vegetables (1 = yes)	99
Fruits	Grew fruits (1 = yes)	49
Cattle	Reared cattle (1 = yes)	61
Sheep	Reared sheep (1 = yes)	3
Goats	Reared goats (1 = yes)	67
Chicken	Reared chicken (1 = yes)	85
Market participation	Sold crop and livestock (1 = yes)	50
Market intensity (mean [SD]; median)	Total crop sold over total crop production	0.1 (0.5); 0.0
Age (mean [SD]; median)	Age of household head (years)	50.7 (14.6); 48
Gender	Gender of household head (1 = male)	72
Marital	Marital status of head (1 = married)	75
Education	Secondary education and above (1 = yes)	53
Household size (mean [SD]; median)	Household size	5.7 (2.4); 5.0
Orphans (mean [SD]; median)	Number of orphans	0.5 (0.9); 0.0
Chronically ill (mean [SD]; median)	Number of chronically ill	0.1 (0.4); 0.0
Land size (mean [SD]; median)	Total land owned (hectares)	3.0 (2.2); 2.5
Total income (mean [SD]; median)	Total household income (USD)	185.0 (405.0); 75
Number of observations		2,815

Notes: Values are % unless specified as (mean [SD]; median). For all continuous variables, the median is reported, especially for age and income which are skewed.

Table 3. Proportion of households which had consumed foods from each food group and main sources of these foods consumed

	Consumption		Main source					
			Own production		Purchased		Other	
Food group	*N*	Consumed (%)	*N*	%	*n*	%	*N*	%
Cereals	2,805	99.0	2,010	72.6	535	19.3	223	8.1
Roots and tubers	2,799	25.3	440	62.5	218	31.0	46	6.5
Nuts and pulses	2,795	43.6	940	77.3	194	16.0	82	6.7
Green leafy vegetables	2,802	72.1	1,642	81.5	303	15.0	70	3.5
Fruits	2,802	37.1	598	58.4	242	24.1	184	17.5
Meats – beef and poultry	2,805	41.3	534	46.4	544	47.3	73	6.3
Fish	2,789	29.6	42	5.1	722	87.7	59	7.2
Eggs	2,799	22.0	491	80.5	105	17.2	14	2.3
Milk and dairy products	2,799	24.4	268	39.4	379	55.7	33	4.9
Sugar and sweets	2,792	84.9	52	2.2	2,256	94.5	55	3.3
Oils and fats	2,782	94.3	184	7.0	2,369	90.7	59	2.3
Condiments, spices, and beverages	2,767	95.0	52	2.0	2,519	96.2	48	1.8

Table 4. Proportion of youngest child who had consumed foods from each food group

Food group	*N*	Consumed (%)
Infant formula	506	11.07
Cereal porridge	506	56.76
Fortified baby formula	505	10.89
Cereals	506	78.74
Orange vegetables	506	23.87
Tubers	506	20.12
Green vegetables	506	40.72
Orange fruits	505	6.53
Other vegetables and fruits	504	48.61
Organ meat	503	10.74
Red meat	505	24.55
Poultry	501	20.16
Eggs	504	25.0
Fish	503	14.51
Pulses	502	23.11
Nuts	502	50.40
Milk products	502	21.91
Oils	498	63.86
Sugary foods	501	27.15
Other solids	493	13.18
Plain water	501	94.41
Milk	498	26.71
Fizzy drinks	502	16.14
Maheu	503	43.17
Fruit juice	492	7.52
Tea	502	53.78
Other liquids	481	4.16

Household dietary diversity and characteristics of HDDS tertiles

In this section, we categorized household into three levels to understand the proportions of household dietary diversity. Since there are no universal cut-offs for categorizing households according to their HDDS, the sample distribution was divided into HDDS tertiles which were characterized as low (0–5), moderate (6–7), and high (8–12) dietary diversity (23, 33). Figure 1 shows that Mt Darwin, Mutare and Makoni had a higher proportion of households with low dietary diversity relative to other districts. On the contrary, Mutasa, Kwekwe and Gokwe South had higher proportion of households with high dietary diversity. About 56 and 52% of the households were categorized as having high diversity in Mutasa and Kwekwe districts, respectively. Higher dietary diversity was confined to districts located in relatively high rainfall regions.

Econometric results

Nutrition education, farm production diversity, and commercialization

Table 5 shows estimates of the association between nutrition education and dietary diversity. Results from the negative binomial regression show that nutrition education and in particular access to child feeding and care information has a positive and significant association with household, women, and children dietary diversity. Nutrition education on child feeding and care practices increases household, women, and child nutrition by 3, 9 and 24%, respectively.

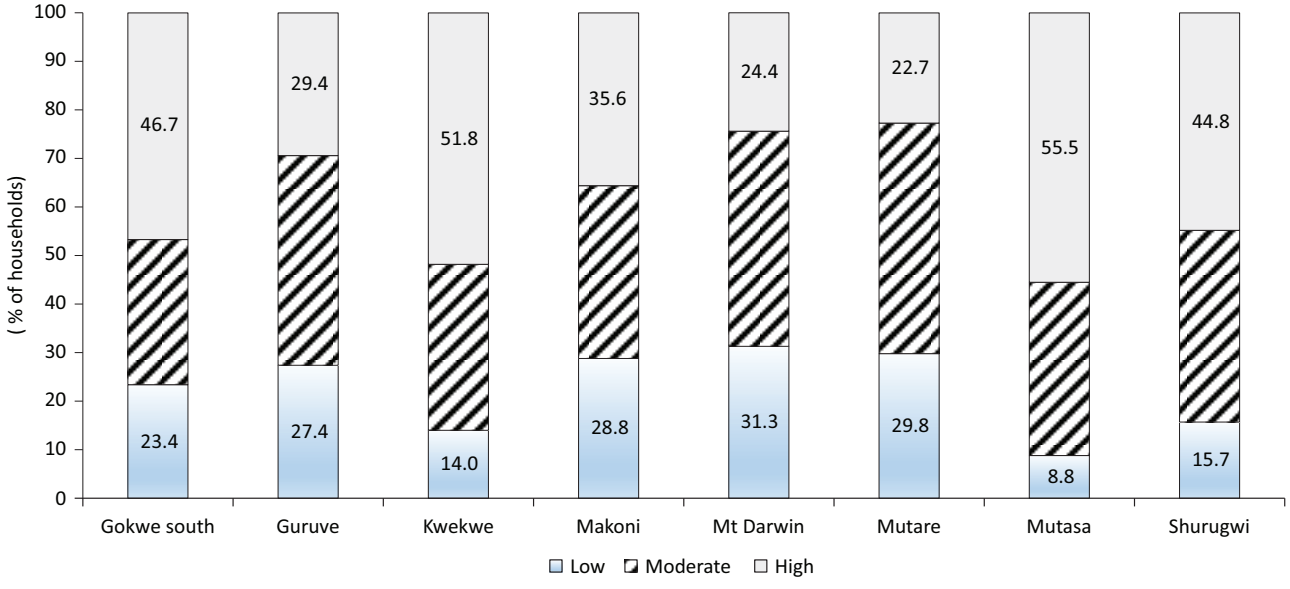


Fig. 1. Proportion of households by dietary diversity tertile.

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276

Table 5. Nutrition education, farm production diversity, and commercialization on household, women, and child dietary diversity

	HDDS	WDDS	CDDS
	IRR	IRR	IRR
Nutrition information	1.00 (0.97–1.03)	0.98 (0.94–1.03)	1.03 (0.89–1.20)
Child feeding and care	1.03** (1.00–1.06)	1.09*** (1.04–1.14)	1.24** (1.04–1.50)
Farm production diversity	1.03*** (1.03–1.04)	1.04*** (1.03–1.05)	1.01 (0.98–1.05)
Market participation	1.06*** (1.04–1.09)	1.13*** (1.09–1.16)	1.15*** (1.04–1.28)
Age	1.00 (1.00–1.00)	1.00** (1.00–1.00)	1.00** (1.00–1.01)
Gender	0.99 (0.95–1.02)	1.01 (0.95–1.07)	0.96 (0.83–1.12)
Marital	1.02 (0.98–1.06)	1.00 (0.94–1.07)	1.11 (0.92–1.33)
Education	1.06*** (1.03–1.08)	1.07*** (1.03–1.11)	1.14** (1.01–1.28)
Household size	1.00 (1.00–1.00)	0.99** (0.98–1.00)	0.99 (0.97–1.02)
Orphans	1.00 (0.99–1.01)	1.01* (0.99–1.03)	1.04 (0.98–1.10)
Chronically ill	0.99 (0.96–1.01)	1.00 (0.96–1.04)	0.93 (0.77–1.14)
Land size	1.00 (1.00–1.01)	1.01*** (1.00–1.02)	0.98 (0.96–1.01)
Total income	1.00*** (1.00–1.00)	1.00*** (1.00–1.00)	1.00 (1.00–1.00)
Gender of child (male)	–	–	1.03 (0.93–1.14)
District dummies	Yes	Yes	Yes
Constant	5.27*** (4.92–5.65)	2.80*** (2.51–3.12)	3.32*** (2.32–4.75)
No. of observations	2,801	2,272	499

HDDS, household dietary diversity score; WDDS, women dietary diversity score; CDDS, child dietary diversity score; IRR, incidence rate ratios; CI, confidence interval.

The dependent variables are household, women, and CDDS. Models were estimated with negative binomial estimator. IRRs are shown with 95% CI in parentheses. *, **, and *** Statistically significant at the 10, 5, and 1% level, respectively.

Farm diversification has a positive and significant association with household and women dietary diversity. The sample consists of subsistence-oriented households, who consume the large part of what is produced on the farm and these results are expected. Producing one additional crop or livestock species leads to a 3 and 4% increase in household and women dietary diversity, respectively. Yet, the effects are relatively small. Commercialization is associated with positive nutritional outcomes for household, women, and children. Market participation results in 6, 13, and 15% increase in household, women, and child dietary diversity, respectively. This also confirms the result that children relied on purchased foods.

Nutrition education, crop and livestock diversification, and commercialization

In Table 6, results from the same type of regression models are shown, but using the crop and livestock species counts as separate independent variables instead of farm production diversity. Nutrition education increases household, women, and children dietary diversity by 3, 9 and 25%, respectively. Increasing crop diversity by one crop species is associated with only a 4 and 5% increase in the number of food groups consumed by the household and women, respectively. Livestock diversity is positively associated with both household and individual dietary diversity. Market participation is associated with 6, 13, and 16% increase in household, women, and children dietary diversity, respectively. Furthermore, education of household head positively influenced household, women, and child nutrition.

Association between individual agricultural practices and nutrition

In this section, we assessed which agricultural practices might play a greater role in shaping household and women nutrition patterns in the sample (27). With regard to access to information on child feeding and care practices, our results are still robust and suggest that nutrition education is positively and significantly associated with women and child nutrition (Table 7). Nutrition education improves women and child nutrition by 8 and 24%, respectively. We decomposed the crop and livestock diversity to explore the association between individual farming practices and nutrition indicators. Results indicated that the cultivation of pulses and fruits were associated with a significant increase in household, women, and children dietary diversity. The cultivation of pulses increased household, women, and children dietary diversity by 19, 22, and 12%, respectively. Vegetables increased household and

Table 6. Nutrition education, crop and livestock diversity, and commercialization on household, women, and child dietary diversity

	HDDS	WDDS	CDDS
	IRR	IRR	IRR
Nutrition information	1.00 (0.97–1.03)	0.98 (0.93–1.03)	1.03 (0.89–1.19)
Child feeding and care	1.03** (1.00–1.06)	1.09*** (1.04–1.14)	1.25** (1.05–1.50)
Crop diversity	1.04*** (1.02–1.05)	1.05*** (1.03–1.07)	0.98 (0.93–1.04)
Livestock diversity	1.03*** (1.02–1.04)	1.03*** (1.02–1.05)	1.04* (1.00–1.09)
Market participation	1.06*** (1.04–1.08)	1.13*** (1.09–1.16)	1.16*** (1.04–1.30)
Age	1.00 (1.00–1.00)	1.00** (1.00–1.00)	1.00** (1.00–1.01)
Gender	0.99 (0.95–1.02)	1.01 (0.95–1.07)	0.96 (0.83–1.12)
Marital	1.02 (0.98–1.06)	1.00 (0.94–1.07)	1.11 (0.92–1.33)
Education	1.06*** (1.03–1.08)	1.07*** (1.03–1.11)	1.15** (1.02–1.29)
Household size	1.00 (0.99–1.00)	0.99** (0.98–1.00)	0.99 (0.97–1.02)
Orphans	1.00 (0.99–1.01)	1.01* (1.00–1.03)	1.04 (0.98–1.11)
Chronically ill	0.99 (0.96–1.01)	1.00 (0.96–1.04)	0.93 (0.77–1.13)
Land size	1.00 (1.00–1.01)	1.01*** (1.00–1.02)	0.99 (0.96–1.02)
Total income	1.00*** (1.00–1.00)	1.00*** (1.00–1.00)	1.00 (1.00–1.00)
Gender of child (male)	–	–	1.03 (0.93–1.14)
District dummies	Yes	Yes	Yes
Constant	5.25*** (4.90–5.64)	2.77*** (2.49–3.10)	3.28*** (2.24–4.79)
No. of observations	2,801	2,272	499

HDDS, household dietary diversity score; WDDS, women dietary diversity score; CDDS, child dietary diversity score; IRR, incidence rate ratios; CI, confidence interval.

The dependent variables are household, women, and CDDS. Models were estimated with negative binomial estimator. IRRs are shown with 95% CI in parentheses. *, **, and ***Statistically significant at the 10, 5, and 1% level, respectively.

Table 7. Regression analysis of nutrition education, individual crop and livestock production practices, and commercialization on household and individual-level dietary diversity

Production system	Individual practice	HDDS	WDDS	CDDS
		IRR	IRR	IRR
Nutrition education	Nutrition information	1.00 (0.97–1.02)	0.97 (0.93–1.02)	1.00 (0.87–1.16)
	Child feeding and care	1.02 (1.00–1.05)	1.08*** (1.04–1.13)	1.24** (1.05–1.48)
Crop	Pulses	1.19*** (1.17–1.21)	1.22*** (1.18–1.26)	1.12** (1.00–1.26)
	Vegetables	1.25*** (1.11–1.42)	1.27*** (1.11–1.45)	1.31 (0.89–1.94)
	Fruits	1.24*** (1.21–1.26)	1.23*** (1.19–1.27)	1.18*** (1.06–1.31)
Livestock	Cattle	1.03*** (1.01–1.06)	1.04** (1.00–1.08)	1.07 (0.95–1.21)
	Goats	1.05*** (1.03–1.07)	1.07*** (1.03–1.10)	1.09 (0.97–1.22)
	Chickens	1.02 (0.99–1.04)	0.99 (0.95–1.04)	0.88* (0.76–1.01)
Market	Market participation	1.04*** (1.03–1.06)	1.11*** (1.07–1.14)	1.15*** (1.04–1.28)
	Constant	3.81*** (3.33–4.36)	2.08*** (1.77–2.45)	2.48*** (1.46–4.20)
	No. of observations	2,801	2,272	499

HDDS, household dietary diversity score; WDDS, women dietary diversity score; CDDS, child dietary diversity score; IRR, incidence rate ratios; CI, confidence interval.

The dependent variables are household, women, and CDDS. Models were estimated with negative binomial estimator. IRRs are shown with 95% CI in parentheses. *, **, and ***Statistically significant at the 10, 5, and 1% level, respectively. Model estimated with same covariates as in Table 6.

women dietary diversity by 25 and 27%, respectively. Fruit production is associated with an increase in household, women, and children dietary diversity. Goat rearing was significant and positively correlated with household and women dietary diversity. Goat rearing increased household and women dietary diversity by 5 and 7%, respectively. Commercialization is positively and significantly associated with household, women, and child nutrition.

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276

Robustness checks

We ran a series of robustness checks. First, we re-estimated Equation 2 with commercialization measured as market intensity instead of participation (Table 8). Results confirm that market intensity is positive and significantly associated with household and women nutrition. Study findings do not seem to be driven by the way commercialization is measured. Furthermore, access to child nutrition information positively influences women and children dietary diversity. In addition, results display similar findings and confirm that pulses and fruits are positively associated with household, women, and child dietary diversity. Our results are therefore quite robust.

Second, we reran the model for crop and livestock diversity and market participation as presented earlier in Table 6 with a stepwise exclusion of relevant control variables in the model specification (27, 34). With these variables removed from the model (Table 9), we found that

Table 8. Regression analysis of nutrition education, individual crop and livestock production practices, and commercialization on household and individual-level dietary diversity

	Individual practice	HDDS	WDDS	CDDS
		IRR	IRR	IRR
Nutrition education	Nutrition information	1.00 (0.98–1.03)	0.99 (0.94–1.03)	1.02 (0.89–1.18)
	Child feeding and care	1.02 (0.99–1.05)	1.08*** (1.03–1.13)	1.23** (1.03–1.47)
Crop	Pulses	1.19*** (1.17–1.21)	1.22*** (1.18–1.26)	1.13** (1.01–1.27)
	Vegetables	1.26*** (1.12–1.43)	1.29*** (1.13–1.47)	1.30 (0.88–1.94)
	Fruits	1.24*** (1.21–1.26)	1.23*** (1.19–1.27)	1.20*** (1.08–1.33)
Livestock	Cattle	1.03*** (1.01–1.05)	1.04** (1.00–1.07)	1.06 (0.94–1.19)
	Goats	1.05*** (1.03–1.07)	1.07*** (1.04–1.11)	1.09 (0.97–1.22)
	Chickens	1.02 (0.99–1.05)	1.00 (0.95–1.04)	0.89 (0.77–1.03)
Market	Market intensity	1.10*** (1.05–1.16)	1.16*** (1.06–1.26)	0.98 (0.74–1.30)
	Constant	3.84*** (3.36–4.39)	2.11*** (1.80–2.48)	2.61*** (1.54–4.43)
	No. of observations	2,801	2,272	499

HDDS, household dietary diversity score; WDDS, women dietary diversity score; CDDS, child dietary diversity score; IRR, incidence rate ratios; CI, confidence interval.

The dependent variables are household, women, and CDDS. Models were estimated with negative binomial estimator. IRRs are shown with 95% CI in parentheses. *, **, and ***Statistically significant at the 10, 5, and 1% level, respectively. Model estimated with same covariates as in Table 6.

Table 9. Robustness checks: nutrition education, crop and livestock diversity, and commercialization on household and women dietary diversity

	Panel A: Head characteristics (age, sex, marital, and education) excluded			Panel B: Wealth (land, income) excluded		
	HDDS	WDDS	CDDS	HDDS	WDDS	CDDS
	IRR	IRR	IRR	IRR	IRR	IRR
Nutrition information	1.00 (0.97–1.03)	0.98 (0.94–1.03)	1.03 (0.89–1.20)	1.00 (0.97–1.03)	0.98 (0.94–1.03)	1.02 (0.88–1.18)
Child feeding and care	1.03** (1.00–1.06)	1.09*** (1.04–1.14)	1.24** (1.04–1.48)	1.03** (1.00–1.07)	1.09*** (1.04–1.14)	1.26** (1.06–1.50)
Crop diversity	1.04*** (1.03–1.05)	1.05*** (1.04–1.07)	0.99 (0.94–1.04)	1.04*** (1.03–1.05)	1.06*** (1.04–1.07)	0.98 (0.93–1.03)
Livestock diversity	1.03*** (1.02–1.04)	1.04*** (1.02–1.05)	1.04* (1.00–1.09)	1.03*** (1.02–1.04)	1.04*** (1.02–1.05)	1.05** (1.00–1.09)
Market participation	1.06*** (1.04–1.09)	1.13*** (1.09–1.16)	1.16*** (1.05–1.30)	1.07*** (1.05–1.09)	1.14*** (1.10–1.17)	1.18*** (1.06–1.31)
Constant	5.59*** (5.32–5.87)	3.10*** (2.86–3.36)	4.48*** (3.29–6.09)	5.24 (4.89–5.62)	2.75*** (2.47–3.08)	3.26*** (2.23–4.76)
Observations	2,801	2,272	499	2,814	2,282	501

HDDS, household dietary diversity score; WDDS, women dietary diversity score; CDDS, child dietary diversity score; IRR, incidence rate ratios; CI, confidence interval.

The dependent variables are household, women, and CDDS. Models were estimated with negative binomial estimator. IRRs are shown with 95% CI in parentheses. *, **, and ***Statistically significant at the 10, 5, and 1% level, respectively. Model estimated with same covariates as in Table 6.

the influence of nutrition education, crop and livestock diversity, and commercialization on household, women, and child nutrition remained significant and positive, thereby providing evidence for the overall robustness of the model. We interpret this as evidence that the main results do not suffer from omitted variable bias (18).

Discussion

Most households consumed starchy staples, whereas few consumed eggs and animal-based foods. Similar results on consumption of eggs were found in Haiti (33), while Galbete et al. (35) found that diets were concentrated on starchy foods and animal-based products in rural and urban Ghana, respectively. Households' own agricultural production was the main source of foods consumed the day before the survey.

To our knowledge, only few studies have analyzed the role of nutrition education on household and individual-level nutrition. In addition, this is a unique study that jointly examines the effects of nutrition education, farm production diversity, and commercialization on household, women, and children dietary diversity in a developing country context. The results of this study clearly support the role of nutrition education for enhancing household and individual nutrition in Zimbabwe. These findings resonate with Hirvonen, Hoddinott, Minten and Stifel (1) who found that nutrition knowledge leads to considerable improvements in children's dietary diversity in Ethiopia. BCC and nutrition-specific approaches that target women and children are needed to accelerate progress toward improved nutrition (4). The positive association of farm production diversity on dietary diversity confirms the findings of Koppmair, Kassie and Qaim (21) and Malapit, Kadiyala, Quisumbing, Cunningham and Tyagi (14), highlighting the crucial role of farm production diversity on improving household and women dietary diversity. Similarly, Sibhatu, Krishna and Qaim (18) found the positive association between farm production diversity and dietary diversity. We found no association between farm production diversity and child dietary diversity. These results contradict other study findings (4, 21, 34). Our study measured dietary diversity in relatively younger children (6–23 months) compared to other studies, for example, by Koppmair, Kassie and Qaim (21) and Saaka, Osman and Hoeschle-Zeledon (4) that included children up to 5 years. Our results are partly explained by the fact that younger children tend to rely on purchased foods and less on foods from own production.

Crop diversity was significantly and positively associated with household and women dietary diversity and not children dietary diversity. In rural Malawi, Koppmair, Kassie and Qaim (21) and Jones, Shrinivas and Bezner-Kerr (8) found similar results that crop diversification improves dietary diversity. Livestock diversity is positively associated with both household and individual dietary diversity. However, the effects are relatively smaller, suggesting that substantial improvement in dietary diversity would require very high levels of crop and livestock diversity if these were the only strategies available. Other studies found similar results that livestock improves nutrition (36, 37). Kabunga, Ghosh and Webb (36) found that ownership of improved dairy cows enhanced household welfare and child nutrition in Uganda. In Northern Rwanda, Rawlins, Pimkina, Barrett, Pedersen and Wydick (37) highlight the positive association between household ownership of dairy cows and child linear growth.

Results indicated that the cultivation of pulses and fruits were associated with a significant increase in household, women, and children dietary diversity. The important contribution of pulses for nutrition is also highlighted in Kenya (27). Goat rearing was significant and positively correlated with household and women dietary diversity. These results suggest that crop–livestock integration is crucial for improved nutrition. The preservation and storage of fodder for livestock feeding in dry season is one crop–livestock integration activity that needs to be promoted to enhance livestock nutrition. Access to markets for buying food and for selling farm produce increased household, women, and children dietary diversity. Various scholars found similar results for Malawi (21) and Ethiopia (1, 38). Hence, improving access to markets through better infrastructure and institutions is a promising strategy to improve nutrition.

Conclusion and policy implications

This study investigated the role of nutrition education, farm production diversity, and commercialization on household, women, and child dietary diversity. We used data collected in 2016 in eight LFSP districts in Zimbabwe. There is renewed attention on the factors that directly affect household and individual-level nutritional status, and efforts are being made to ensure that caregivers and individuals understand which diets are appropriate for which age groups. In turn, this has led to the use of BCC interventions that seek to improve household and individual nutrition knowledge and encourage behavior change adoption. BCC interventions are also expected to improve decision-making on nutrition and child care since they encourage active participation of both men and women. In this study, we find that nutrition knowledge leads to improvements in household, women, and children's dietary diversity. Overall, results demonstrate the potential value of promoting nutrition education via BCC interventions to enhance household and individual-level nutrition. BCC strategies, for example, messages on healthy eating and balanced diets should be disseminated to households, women, children, and men through various platforms, for example, print and electronic media, food fairs, field days, and school curriculums and dramas to enhance improved nutrition.

The results show that farm production diversity had a strong and positive association with household and

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276

women dietary diversity. These results suggest that farm production diversification has the potential to improve household and women nutrition, highlighting the importance of individual-level analysis. Furthermore, when farm production is disaggregated, our results show that crop diversity is positively associated with household and women dietary diversity. The association between individual farming practices and nutrition shows interesting results. The cultivation of pulses and fruits is positively associated with household, women, and child dietary diversity, while vegetables and goats had significant relationship with household and women dietary diversity only. This suggests that interventions that promote pulses, vegetables, fruits, and small stock production maximize nutritional content of diets and are beneficial for household, women, and child nutrition.

Market participation is positively associated with household, women, and child dietary diversity. Smallholder farmers have limited access to markets to sell their products. They often live in remote locations where infrastructure is poor and buyers do not travel. In addition, they have poor skills to negotiate with buyers and also lack access to credit. Therefore, improving access to markets through better infrastructure and institutions and promoting programs that link farmers to the market are promising strategies to improve nutrition.

These findings demonstrate the importance of household and individual-level analysis. Furthermore, results demonstrate the significant role of women crops: pulses and vegetables on women and child nutrition. Interventions that minimize trade-offs between women child care and agricultural production should be promoted, for example, the adoption and use of labor-saving technologies such as fuel-efficient stoves, shellers, and ridgers. Taken together, the results show the need to promote nutrition education, farm production diversification, and commercialization as complementary interventions for improving household and individual nutrition.

Limitations

This article is based on cross-sectional data which were collected at a single point in time. This study has limitations in that we cannot account for seasonality in diets. We have data on whether the household, women, and child consumed different foods, but we do not have information on the quantities consumed. In addition to this, as the study considered only the 24-h recall method, it might not accurately reflect participants past feeding dietary habit. Moreover, there might be a recall bias, and being a self-reported study might not give the exact figure of the minimum dietary diversity practice. Furthermore, establishing causality with cross-section data is a challenge. Even if we are able to find a good instruments, the instrumental variable regression results will only be as good as the underlying instruments. Future research might need to consider use of panel data to address these shortcomings. Finally, the study findings are based on a LFSP targeting the poor and vulnerable households and as such our results are not nationally representative.

Acknowledgements

The authors are grateful to the farmers and extension staff in the survey districts for their enthusiasm and collaboration in providing information during fieldwork. We are grateful to the UK Department for International Development through Food and Agriculture Organization for funding the research. We acknowledge the research assistants for providing constructive and very useful comments that improved the survey tool as well as collecting the data.

Conflicts of interest and funding

The authors declare that they have no conflicts of interest. The article is original work and has not been submitted for publication elsewhere.

References

1. Hirvonen K, Hoddinott J, Minten B, Stifel D. Children's diets, nutrition knowledge, and access to markets. World Dev 2017; 95: 303–15.
2. Jones AD. Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low- and middle-income countries. Nutr Rev 2017; 75(10): 769–82.
3. LFSP. Livelihoods and Food Security Programme Zimbabwe. Available from: https://lfspzim.com/what-is-lfsp/background/projects/ [cited 3 March 2018].
4. Saaka M, Osman SM, Hoeschle-Zeledon I. Relationship between agricultural biodiversity and dietary diversity of children aged 6–36 months in rural areas of Northern Ghana. Food Nutr Res 2017; 61: 1391668.
5. Pelto GH, Martin SL, van Liere MJ, Fabrizio CS. Perspectives and reflections on the practice of behaviour change communication for infant and young child feeding. Matern Child Nutr 2016; 12: 245–61.
6. Dewey KG, Adu-Afarwuah S. Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. Matern Child Nutr 2008; 4(Suppl 1): 24–85.
7. Zimbabwe Vulnerability Assessment Committee. Zimbabwe Vulnerability Assessment Committee (ZimVAC) rural livelihoods assessment. Harare, Zimbabwe; 2016. Available from: http://www.fnc.org.zw/downloads/Bulletins/2016%20Bulletins/ZimVAC%202016%20Rural%20Livelihoods%20Assessment.pdf [cited 4 July 2017].
8. Jones AD, Shrinivas A, Bezner-Kerr R. Farm production diversity is associated with greater household dietary diversity in Malawi: findings from nationally representative data. Food Policy 2014; 46: 1–12.
9. Carletto G, Ruel M, Winters P, Zezza A. Farm-level pathways to improved nutritional status: introduction to the special issue. J Dev Stud 2015; 51: 945–57.
10. Ruel MT, Alderman H. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet 2013; 382: 536–51.

11. Arimond M, Wiesmann D, Becquey E, Carriquiry A, Daniels MC, Deitchler M, et al. Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. J Nutr 2010; 140: 2059S–69S.
12. Akaakohol MA, Aye GC. Diversification and farm household welfare in Makurdi, Benue State, Nigeria. Dev Stud Res. 2014; 1: 168–75.
13. Carletto C, Corral P, Guelfi A. Agricultural commercialization and nutrition revisited: empirical evidence from three African countries. Food Policy 2017; 67: 106–18.
14. Malapit HJL, Kadiyala S, Quisumbing AR, Cunningham K, Tyagi P. Women's empowerment mitigates the negative effects of low production diversity on maternal and child nutrition in Nepal. J Dev Stud. 2015; 51: 1097–123.
15. Pellegrini L, Tasciotti L. Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries. Can J Dev Stud 2014; 35: 211–27.
16. Seng K. The effects of nonfarm activities on farm households' food consumption in rural Cambodia. Dev Stud Res 2015; 2: 77–89.
17. Quisumbing AR, Meinzen-Dick R, Raney TL, Croppenstedt A, Behrman JA, Peterman A. Gender in agriculture. Dordrecht: Springer Netherlands; 2014.
18. Sibhatu KT, Krishna VV, Qaim M. Production diversity and dietary diversity in smallholder farm households. Proc Natl Acad Sci U S A 2015; 112: 10657–62.
19. Shively G, Sununtnasuk C. Agricultural diversity and child stunting in Nepal. J Dev Stud 2015; 51: 1078–96.
20. Snapp SS, Fisher M. 'Filling the maize basket' supports crop diversity and quality of household diet in Malawi. Food Security 2015; 7: 83–96.
21. Koppmair S, Kassie M, Qaim M. Farm production, market access and dietary diversity in Malawi. Public Health Nutr 2017; 20(2): 325–35.
22. Swindale A, Bilinsky P. Household dietary diversity score (HDDS) for measurement of household food access: indicator guide: indicator guide (v. 2): food and nutrition technical assistance project. FHI360/FANTA: Washington, DC; 2006.
23. Swindale A, Ohri-Vachaspati P. Measuring household food consumption: a technical guide: food and nutrition technical assistance project. FHI360/FANTA: Washington, DC; 2004.
24. Muhoozi GKM, Atukunda P, Mwadime R, Iversen PO, Westerberg AC. Nutritional and developmental status among 6- to 8-month-old children in southwestern Uganda: a cross-sectional study. Food Nutr Res 2016; 60: 30270.
25. Kansiime MK, Watiti J, Mchana A, Jumah R, Musebe R, Rware H. Achieving scale of farmer reach with improved common bean technologies: the role of village-based advisors. J Agric Educ Extension 2018; 1071: 1–18.
26. Kiptot E, Franzel S. Voluntarism as an investment in human, social and financial capital: evidence from a farmer-to-farmer extension program in Kenya. Agric Hum Values 2014; 31: 231–43.
27. Romeo A, Meerman J, Demeke M, Scognamillo A, Asfaw S. Linking farm diversification to household diet diversification: evidence from a sample of Kenyan ultra-poor farmers. Food Security 2016; 8: 1069–85.
28. Cameron AC, Trivedi PK. Microeconometrics using Stata. College Station, TX: Stata Press; 2010.
29. Greene WH. Econometric analysis. 7th ed. Boston, MA: Prentice Hall; 2012.
30. Hilbe JM. Negative binomial regression. 2nd ed. Cambridge: Cambridge University Press; 2011.
31. Wilber ST, Fu R. Risk ratios and odds ratios for common events in cross-sectional and cohort studies. Acad Emerg Med 2010; 17: 649–51.
32. Long JS, Freese J. Regression models for categorical dependent variables using Stata. [place unknown]: [publisher unknown]; 2014.
33. Pauzé E, Batal M, Philizaire Y, Blanchet R, Sanou D. Determinants of diet quality among rural households in an intervention zone of Grande Anse, Haiti. Food Security 2016; 8: 1123–34.
34. Galbete C, Nicolaou M, Meeks KA, de-Graft Aikins A, Addo J, Amoah SK, et al. Food consumption, nutrient intake, and dietary patterns in Ghanaian migrants in Europe and their compatriots in Ghana. Food Nutr Res 2017; 61: 1341809.
35. Kabunga NS, Ghosh S, Webb P. Does ownership of improved dairy cow breeds improve child nutrition? A pathway analysis for Uganda. PLoS One 2017; 12: e0187816.
36. Hirvonen K, Hoddinott J. Agricultural production and children's diets: evidence from rural Ethiopia. Agric Econ 2017; 48: 469–80.
37. Rawlins R, Pimkina S, Barrett CB, Pedersen S, Wydick B. Got milk?: the impact of Heifer International's livestock donation programs in Rwanda on nutritional outcomes. Food Policy 2014; 44: 202–13.
38. Sibhatu KT, Qaim M. Rural food security, subsistence agriculture, and seasonality. PLoS One 2017; 12: e0186406.

***Conrad Murendo**
International Crops Research Institute for the Semi-Arid Tropics
P. O. Box 776
Bulawayo, Zimbabwe
Email: cmurendo@hotmail.com

Citation: Food & Nutrition Research 2018, **62**: 1276 - http://dx.doi.org/10.29219/fnr.v62.1276