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Impact of agricultural diversity and market accessibility on dietary outcomes for households, women, and children in Bangladesh

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A B S T R A C T

Diversified agricultural production increases household food diversity, especially in developing nations where subsistence farming is prevalent. The goal of this study was to determine the factors associated with farm production, commercialization, livestock rearing, and socio-demographic status on dietary diversity of households (HDD), women (WDD) and children (CDD). Data were obtained from 300 randomly selected households using two-stage random sampling techniques. HDD, WDD and CDD were measured using 24-hour dietary recall data. A binary logistic regression and negative binomial regression model were applied to find the significant factors associated with HDD, WDD, and CDD. The mean values of HDD, WDD, and CDD were 7.59, 6.62, and 4.74. Cereals were consumed by 99% of participants. The adequate and inadequate HDD of the participants were 49.3% and 50.7%. As farm production increases, the odds of HDD and CDD scores increase by 1.35 units and 18%. HDD and WDD were 0.26 and 032 times lower in households with six or fewer members compared to those with more than six members. The HDD and WDD were 4.33 and 7.92 times higher for attending market participation. The HDD and WDD were 0.16 and 0.36 times lower for the people who reared domestic animals. The WDD was 0.46 times lower for family income less than 25000 taka. The CDD score decreases by 0.61 with attending market participation. Better market access and farm production diversity can be used to increase HDD and WDD, whereas CDD increases with production diversity. The results emphasize the necessity of improving market access, family income and crop-livestock integration for improved nutrition.

Keywords: Production diversity, Commercialization, Dietary diversity, Livestock, Bangladesh

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Introduction

The quality of food consumption can be measured by how many different foods are available in a household and how many nutrients are included in an individual's diet. When it comes to measure nutritional quality and sufficiency, it is common practice to look at dietary diversity (DD). To meet the WHO's minimum dietary diversity recommendations, children aged 6 to 23 months must have received at least four different types of foods from the seven standard food groups the day before, including grains, roots and tubers, legumes and nuts, dairy products, meat, fish, poultry, and organ meats, eggs, vitamin A-rich fruits and vegetables, and other vegetables and fruits (Habtemariam *et al.*, 2021). Increased and consistent income allows households to acquire and consume a variety of food items (Thorne-Lyman *et al.*, 2010). Given that the majority of rural households consume a significant percentage of their products, a direct positive relationship between product variety and dietary diversity is feasible (Sibhatu *et al.*, 2015). Diversification may not always be the ideal technique for boosting the dietary diversity of agricultural households due to the loss of economic opportunity from specialization (Jones *et al.*, 2014; Kabir *et al.*, 2022; Tischler *et al.*, 1998). In places with limited resources, monotonous, low-quality meals are normal. When diets of staple foods are mostly based on grains and tubers, excluding vegetables, fruits, and meals derived from animals, there remains a significant risk of different micronutrient deficiencies (Mekuria *et al.*, 2017). To find out the association between production and dietary diversification, market access could play an essential role as a confounding variable. Increased market access and involvement enable smallholder farmers to sell a portion of their harvested crops and proceed to acquire more diverse food. At times, access to markets has been identified as having a more significant influence on dietary diversity than production diversity.

Individuals living close to marketplaces enjoy greater availability of diverse food options year-round. According to a study on the nature and impact of farm products on HDD done in rural and peri-urban areas of in Kenya and Tanzania, it was discovered that dietary variety was higher in peri-urban areas with better market access, even though there was less variety in production (Kissoly *et al.*, 2020). Adopting agricultural technologies significantly impacted food production and availability (Magrini and Vigani, 2016). Aside from these factors, a study done in Bangladesh found a link between household wealth and education with the variety of food in households and better food security (Harris-Fry *et al.*, 2015).

During 2014–2016, it is anticipated that 795 million people globally suffer from malnutrition, with around 780 million living in developing nations (Saaka *et al.*, 2017). Due to the reciprocal interdependence of their basic components, the notion of "Agriculture-Nutrition Linkages" for increasing food and nutrition security has emerged as a new topic of study (Kabir *et al.*, 2022). Diversified agricultural output like rearing livestock and crop production is more likely to supply a diverse choice of foods to the low population segment (Saaka *et al.*, 2017). The majority of research stated that increasing agricultural production diversification improved nutritional diversity (Nandi *et al.*, 2021). If households consume what they produce, it stands to reason that families with different crops and animals should have diverse diets, which is why diverse farm output has been promoted to increase nutritional diversity (Saaka *et al.*, 2017). Agriculture is the primary source of various nutritious meals in underdeveloped nations, and improved agricultural production through diversified farming can significantly impact food availability, diet, and nutrition (Murendo *et al.*, 2018). Household income is increased through commercialization of their crops and livestock as well as farm labor supply. Improved household income may allow households to spend their money more wisely on food and non-food products, such as healthcare, resulting in improved nutrition, health, and welfare (Murendo *et al.*, 2018).

In Malawi, the variety of farm production and selling is connected to the variety of food in homes for mothers and children (Murendo *et al.*, 2018). In Mali, dietary diversity was found to be positively related to women's mean adequacy ratio. DDSs have also been observed to have a strong favorable link with nutrient sufficiency in children (Gupta *et al.*, 2020). No studies were found to examine the effects of farm diversity and commercialization on households, women, and children, especially in Bangladesh. In our study, we have separated the farm production varieties into crops and livestock and studied their specific relationships with households, women's, and children's eating habits, as well as selling. Maximum research articles focused on nutrition outcomes at the household level, but failed to capture the effects at the individual level. We also look into the impact of certain crops and livestock methods on the dietary diversity of households, women, and children. Little research has been done in these areas. The study aimed to examine the influence of production diversity, market participation, rearing domestic animals, and socio-demographic factors on HDD, WDD and CDD.

Materials and Methods

Study design, area and period

A community based cross-sectional study from 17th February to 28th April was conducted at Lohagara and Satkania Upazila of Chattogram District of Bangladesh. According to the Population and Housing Census 2011, the population and household numbers of Lohagara Upazila were 52,873 and 279,913 respectively. The 10.7% population of the Lohagara Upazila lived in urban areas. 12.1% of the population was under the age of 5. Compared to the national average of 51.8%, the literacy rate for those aged 7 and above was 49.2%. The population and household number of Satkania Upazila were 384,806 and 70,808, respectively, whereas 14.1% people lived in urban areas. The literacy rate among those aged 7 and up was 52.7%, which was lower than the 51.8% national average (BBS, 2011).

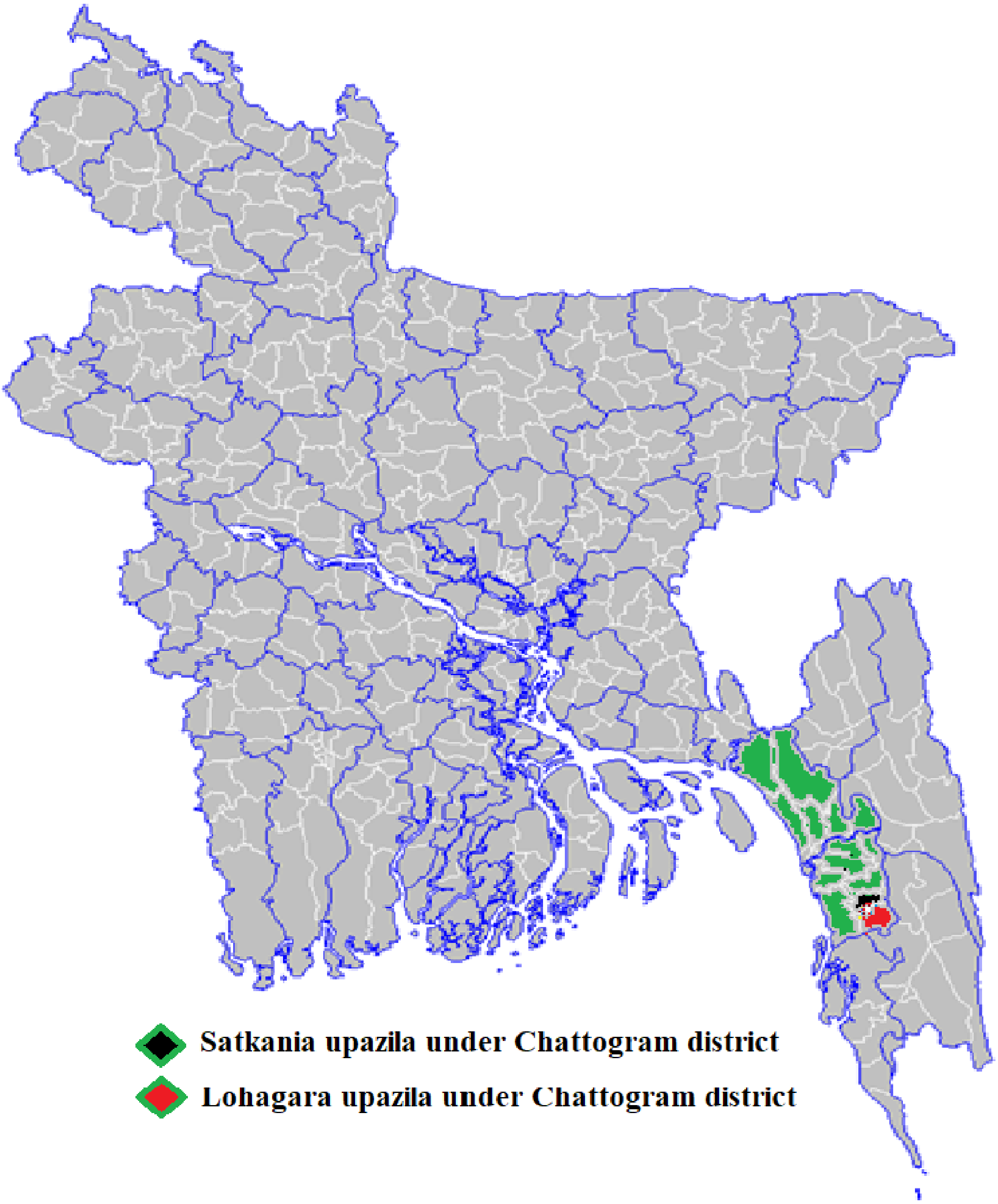

Fig.1. Map of Bangladesh with study area.

Data collection

The structured questionnaire was used to collect data from face-to-face interviews with household persons. There are three primary sections of the survey: socio-demographic factors including the age of the mother, education and occupations of the parents, family type and its members; other section includes livestock rearing, microcredit loan taking, and nutrition knowledge and lastly the dietary diversity was assessed using a 24-hour recall approach. After being adapted and translated into Bengali a structured questionnaire was used from the WHO assessment tool for household feeding practice. To ensure the questionnaire was accurate and consistent, we checked it before beginning the data collection.

Sample size and sampling procedure

A total of 300 participants were included in this study based on a short period of time. The upazila-based households were selected using a stratified random selection process.

Measuring household dietary diversity

A modified Household Dietary Diversity Score (HDDS) (Swindale and Ohri-Vachaspati, 2004) was calculated for each household using recall data on the consumption of foods over the previous 24 hours. The food items were sorted into 12 different food groups, with each group adding to the household score if anyone in the household ate a food item from that group in the last 24 hours. The updated HDDS is a total that ranges from 0 to 12. The food groups used to figure out the updated 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.

Measurement of women's dietary diversity

The individual dietary diversity score of women between the ages of 15 and 49 is used to calculate the women's dietary diversity score (HDDS). Using 24-hour dietary recall data of women's own consumption from 11 food groups - starchy staples, pulses, dark green leafy vegetables, fruits and vegetables high in vitamin A, roots and tubers, other fruits and vegetables, milk and milk products, egg, fish, meat, sugar, and condiments - we compute individual dietary diversity scores (Murendo *et al.*, 2018).

Measurement of child dietary diversity

The quality of each child's food was assessed using the child dietary diversity scores (CDDS). The number of food groups consumed in the previous 24 hours by infants aged 6 to 23 months is used to determine how diverse their diets are. These 16 food groups include 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 (Murendo *et al.*, 2018).

Ethical consideration

This study was conducted in accordance with the ethical statement of the Helsinki Declaration (Rickham, 1964). Written informed consent was obtained from the household head after informing the purpose of the study and assuring the confidentiality of their information and that it was not harmful to the study.

Statistical analysis

Descriptive statistics like percentages, mean, median and standard deviation were applied. A binary logistic regression model was applied to find out the factors of triggering the HDD, CDD and CDD. The models were fit proved by Hosmer and Lemeshow test statistic. The parameters were significantly tested by the likelihood ratio test. Since the mean was lower than the variance for children's dietary diversity (CDD), which shows the over-dispersed model. A negative binomial regression model was applied for CDD to observe the significant factors. The statistical package SPSS version 23.0 was applied for analysis, and 5% level of significance with two two-tailed test was maintained.

Results

Table 1 displays household characteristics. The top portion of this table shows the range of dietary diversity for women and children. The mean dietary diversity of households, women and children was 7.5, 6.62 and 4.74, respectively. Individual dietary diversity was less diverse than household dietary diversity. Of the participants, 49.3% and 50.7% had adequate and inadequate HDD. On average, 2.4 and 3.0 different kinds of animals are reared in farm households. Every home had a garden, and 67% of them grew pulses in addition to vegetables. 50% of the sample homes participated in the market by selling animals or crops. About 23.3% of the total was made up of crop sales. However, only around 10% of the agricultural harvest was actually sold. These results suggest that only a small portion of agricultural yield is traded. Farm households place a high priority on food self-sufficiency and only surplus was sold to the market.

The variables we use as covariates in the different regression model settings are listed in the bottom half of Table 1. Our sample consists of male-headed families, with a mean age of 41.5 and a completion rate of at least a secondary education of 78%. The household sizes ranged from 1 to 8, with a mean of 1.62.

Table 1. Household, farm characteristics and dietary diversity of respondents.

Variables	Description	Value
Household dietary diversity (mean [SD]; median)	Frequency of consumption of food groups	7.59(7.00); 1.44
Women's dietary diversity (mean [SD]; median)	Number of food groups consumed by women	6.62(7); 1.33
Child dietary diversity	Number of food groups consumed by child	4.74(5); 3.82
Farm production diversity (mean [SD]; median)	no. of livestock, no. of crops, and no. of vegetables	3.07 (2.03); 3.00
Crop diversity (mean [SD]; median)	Number of crop species grown	0.18 (0.39); 0.00
Vegetable diversity (mean [SD]; median)	Number of vegetables grown	1.53 (1.21); 2.00
Livestock diversity (mean [SD]; median)	Number of livestock species reared	1.36 (1.13); 2.00
Vegetables	Grew vegetables (1 = yes)	209
Fruits	Grew fruits (1 = yes)	230
Cattle	Reared cattle (1 = yes)	128
Sheep	Reared sheep (1 = yes	1
Goats	Reared goats (1 = yes)	49
Chicken	Reared chicken (1 = yes)	169
Pigeon	Reared chicken (1 = yes)	34
Duck	Reared chicken (1 = yes)	44
Market participation	Sold crop and livestock (1 = yes)	45
Age (mean [SD]; median)	Age of household head (years)	41.58(11.00); 40.00
Gender	Gender of household head (1 = male)	300
Education	Secondary education and above (1 = yes)	236
Household size (mean [SD]; median	Household size	1.62 (2.00); 4.80
Total income (mean [SD]; median)	Total household income (Taka)	25383.33 (12104.46); 25000
Number of observations		300

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 2 shows the food categories that families consumed. Most households consumed cereals (99%), condiments/ spices/beverages (99%), oils/fats (88%), and roots and tubers (84%). The least eaten foods were sugar and sweets (21%) and fruits (30.3%). Vegetables (82.3%), eggs (58.3%), roots and tubers (84%), which were consumed by homes, were primarily produced by the households themselves; in contrast, cereals, oils and fats, sugars and sweets, condiments and spices, fish, meat, and milk products were primarily purchased.

Table 2. Exploration of food sources consumed by the households.

Food groups	Consumption		Own production		Purchased	
	N	%	N	%	N	%
Cereals	297	99.0	2	0.7	298	99.3
Roots and tubers	252	84.0	140	46.7	112	37.3
Nuts and pulses	130	43.3	13	4.3	117	39.0
Green leafy vegetables	247	82.3	122	40.7	125	41.7
Fruits	91	30.3	9	3.0	82	27.3
Meats	189	63.0	4	1.3	185	61.7
Fish	126	42.0	1	0.3	125	41.7
Eggs	175	58.3	93	31.0	82	27.3
Milk and dairy products	154	51.3	55	18.3	99	33.0
Sugar and sweets	64	21.3	0	0.0	64	21.3
Oils and fats	264	88.0	0	0.0	264	88.0
Condiments, spices, and beverages	297	99.0	0	0.0	297	99.0

Table 3 shows the food categories that women and children consumed. The food categories that women consumed cereals (99%), roots and tuber (74.7%), green leafy vegetables (59.7%), vitamin A rich fruits and vegetables (17.7%), others fruits and vegetables (60.7%), meat (55.7%), eggs (56%), fish (37%), nuts and pulses (51%), dairy products (53.7%), sugar, sweets, condiments and spices (95.7%). The food categories that children consumed the most of cereals (62.3%), grains, root or vegetables (3.3%), green vegetables (30%), orange vegetables (10%), juice (18%), and other fruits and vegetables (41.3%). Meat (34.3%), any organ (17%), egg (52.3%), fish (23.3%), orange fruits (13.7%), pulses (27.3%), dairy products (36.6%), food cooked in oil (38.3%), sugar or honey (17.3%) and liquids (53%). Vegetables, eggs, roots and tubers which were consumed by women and children were primarily produced by the households themselves; in contrast, cereals, juice, oils and fats, sugars and sweets, condiments and spices, fish, meat and milk products were primarily purchased.

Table 3. Dietary diversity of women and children among study participants.

Food groups	WDD		CDD	
	Consumption		Consumption	
	N	%	N	%
Cereals	297	99.0	187	62.3
Roots & tubers	224	74.7	10	3.3
Green leafy vegetables	179	59.7	90	30.0
Vitamin A-rich fruits, vegetables	53	17.7	-	-
Other fruits & vegetables	182	60.7	124	41.3
Meat	167	55.7	103	34.3
Eggs	168	56.0	157	52.3
Fish	111	37.0	70	23.3
Nuts and pulses	153	51.0	82	27.3
Dairy products	161	53.7	110	36.7
Sugar, sweets, condiments and spices	287	95.7		
Orange vegetables	-	-	30	10.0
Juice	-	-	54	10.0
Any organ (liver, kidney, heart)	-	-	51	17.0
Orange fruits	-	-	41	13.7
Food cooked in oil or fat	-	-	115	38.3
Any sugar or honey	-	-	52	17.3
Liquids (any other food such as condiments, coffee, tea, beverages)	-	-	159	53.0

A binary logistic regression model was applied to determine the parameter estimates of the HDD scored in Table 4. The model was fitted well (P value=0.09) using the Hosmer and Lemeshow goodness of fit test. The coefficients were tested by using the likelihood ratio test. After adjusting for the confounders, the model was significantly associated with household size, farm production, market participation, and rearing of domestic animals. The HDD was 0.26 times lower for household size members 1 to 6 than for members greater than 6. As farm production increases by one unit (species), the odds of the HDD score increase by 1.35 units. For the people who attended market participation, the HDD was 4.33 times higher for them than for those who did not attend. For the people who reared domestic animals, the HDD was 0.16 times lower than for those who did not rear.

Table 4. Parameter estimates of HDD by using a binary logistic regression model.

Parameter	Estimate	Standard error	P value	Odds ratio (OR)	95% CI
Household size					
1- 6	-1.336	0.538	0.013	0.26	0.09-0.76
>6				1	
Farm production	0.303	0.119	0.011	1.35	1.07-1.71
Market participation					
Yes	1.466	0.581	0.012	4.33	1.39-13.53
No				1	
Rearing domestic animals					
Yes	-1.821	0.470	0	0.16	0.06-0.41
No				1	

Table 5 represents the effect of different factors on WDD. A binary logistic regression model was applied to determine the parameter estimates of the WDD score. The model was fitted well (P value=0.15) by using the Hosmer and Lemeshow goodness of fit test. The coefficients were tested by using a likelihood ratio test. After adjusting the confounders, the model was significantly associated with family income, household size, market participation and rearing domestic animals. The WDD was 0.46 times less likely for people with less than or equal to 25000 taka incoming than for people with greater than or equal to 26000 taka incoming. The WDD was 0.32 times lower for household size members 1 to 6 than for members of greater than 6. The people who attended market participation in the WDD were 7.92 times more likely to attend than not to attend. The people who reared domestic animals the WDD that was 0.36 times lower than those who did not rear.

Table 5. Parameter estimates of WDD by using a binary logistic regression model.

Parameters	Estimate	Standard error	P value	Odds ratio (OR)	95% CI
Family income					
≤ 25000	-0.775	0.382	0.042	0.46	0.22-0.97
>25000				1	
Household size					
≤ 6	-1.153	0.557	0.038	0.32	0.11-0.94
> 6				1	
Market participation					
Yes	2.07	0.62	0.001	7.92	2.35-26.71
No				1	
Rearing domestic animals					
Yes	-1.029	0.458	0.025	0.36	0.15-0.88
No				1	

Table 6 represents the effect of factors on CDD. The CDD score mean was less than the variance. The negative binomial regression model was fitted well in the CDD score (P value=0.49). It was observed from the table that for one one-unit increase in farm production, the CDD rate increases by 18%. The CDD rate among market participation (sale of a product) was 0.61, as low as the rate among non-market participation.

Table 6. Parameter estimates of CDD by using negative binomial distribution.

Parameters	IRR	Confidence interval	P value
Farm production	1.18	1.06-1.30	0.0015
Market Participation			
Yes	0.61	0.39-0.96	0.0321
No	1		

Discussion

The average HDD was 7.59. Of the participants, 99% consume grains, more than 50% consume meat and eggs, and fewer than 50% consume fish, among the other dietary categories. 50.7% of individuals had inadequate dietary diversity, whereas 49.3% of people had enough variety. Similar results on the consumption of eggs were found in (Pauzé *et al.*, 2016), while (Kabunga *et al.*, 2017) found that diets were concentrated on starchy foods and animal-based products in rural and urban Ghana, respectively. The positive link between farm production diversity and variety in the diet supports the results showing how important farm production diversity is for enhancing households' diets and women's dietary diversity (Koppmair *et al.*, 2017; Malapit *et al.*, 2015). Similarly, a positive association was found between farm production diversity and dietary diversity (Sibhatu *et al.*, 2015). We also found an association between farm production diversity and household dietary diversity. These results contradict other study findings (Galbete *et al.*, 2017; Koppmair *et al.*, 2017; Sibhatu *et al.*, 2015). Rearing domestic animals is significantly associated with household dietary diversity. Livestock diversity is linked to both household and individual dietary diversity. However, the impact is quite small, indicating that a big increase in dietary diversity would need very high levels of crop and livestock diversity if these were the only available options. Related article found that crop diversification improves dietary diversity (Koppmair *et al.*, 2017; Jones *et al.*, 2014). Other research found similar findings that livestock enhances nutrition, showing a good connection between having dairy cows in a household and children's height growth (Hirvonen and Hoddinott, 2017; Rawlins *et al.*, 2014). Results indicated that the cultivation of pulses and fruits was associated with a significant increase in household dietary diversity. The important contribution of pulses to nutrition is also highlighted in Kenya (Romeo *et al.*, 2016). Access to markets for buying food and for selling farm produce increased household, women's, and children's dietary diversity. Various scholars found similar results (Koppmair *et al.*, 2017; Hirvonen *et al.*, 2017; Sibhatu and Qaim, 2017).

Therefore, increasing access to markets by enhancing infrastructure and organizations is a hopeful way to improve nutrition. As far as we are aware, very few researchers have examined the impact of farm production and commercialization on the nutrition of women and children. Additionally, this study is distinctive since it explores how dietary variety among households, women, and children in developing countries is affected by diverse agricultural production, family income, household size and commercialization. The positive association of farm production diversity with dietary diversity confirms the findings underlining the vital impact that nutritional diversity for women has on the diversity of farm productivity (Koppmair *et al.*, 2017; Malapit *et al.*, 2015). We did not discover any beneficial associations between domestic animal raising and women's dietary diversity. We discovered a beneficial correlation between children's dietary diversity and agricultural production diversification. Similar outcomes were discovered in other study findings (Saaka *et al.*, 2017; Koppmair *et al.*, 2017; Galbete *et al.*, 2017). Compared to different studies, such as those that included children up to 5 years old, our study measured dietary diversity in relatively younger children (6-23 months) (Koppmair *et al.*, 2017; Saaka *et al.*, 2017).

Results indicated that the family income and household size were associated with a significant increase in women's dietary diversity. Access to marketplaces for the purchase of food and the sale of farm products enhanced the dietary diversity of women. Several researchers discovered comparable outcomes for Malawi and Ethiopia (Koppmair *et al.*, 2017; Hirvonen *et al.*, 2017). Therefore, enhancing market accessibility through stronger institutions and infrastructure is a promising nutrition-enhancing approach. We did not find any correlation between market participation and the variety of children's diets. These outcomes conflict with those of additional research (Koppmair *et al.*, 2017; Hirvonen *et al.*, 2017). The study also examined the total amount of vegetables, fruits, crops, and livestock produced over the last 12 months and how much farmers ate and sold in the market. Our study adds to the existing research to support the idea that having production diversity improves dietary diversity among women.

This study is distinctive because it is the first to start the HDD, WDD, and CDD simultaneously. Limitations are that we cannot account for seasonality in diets; we have data on the sorts of meals consumed by the household, women, and children, but we don't know how much of each food was consumed. Furthermore, because the study only employed the 24-hour recollection approach, the results may not accurately represent the individuals' past food and eating patterns. Furthermore, there might be a remembering bias, and because this was a self-reported study, it's conceivable that the least quantity of dietary diversity was not indicated properly. The study's findings are not nationally representative because of the small sample size.

Conclusion

Economic value, household size, agricultural output, market involvement, and domestic animal rising all substantially impact HDD, WDD and CDD. With an increase in household size, the HDD and WDD score rises. The positive association between farm production diversity on dietary diversity confirms the findings and highlights the crucial role of farm production diversity in improving HDD and CDD. Market participation is favorably related to the variety of HDD and WDD but increases as the CDD. Rearing domestic animals is significantly associated with HDD and WDD. Livestock diversity is linked positively to both the range of households' diversity and individual's diversity. Access to markets for buying food and selling farm products has increased household dietary diversity. Improving market access through better infrastructure and institutions is a promising strategy to improve nutrition. The findings highlight the necessity of commercializing farm production and farm output diversification as supplementary interventions for enhancing household, women's and children's nutrition.

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