Farm production, child dietary intake and household wealth:

Results from a nationally-representative survey in Nepal

Prajula Mulmi (pmulmi@gmail.com)
Helen Keller International, Kathmandu

William A. Masters (william.masters@tufts.edu)
Friedman School of Nutrition and Department of Economics, Tufts University

Steven A. Block (steven.block@tufts.edu)
Fletcher School of International Affairs, Tufts University

Patrick Webb (patrick.webb@tufts.edu)
Friedman School of Nutrition Science and Policy, Tufts University

Selected Paper prepared for presentation at the 2017 Agricultural & Applied Economics Association Annual Meeting, Chicago, Illinois, July 30-August 1

Farm production, child dietary intake and household wealth:

Results from a nationally-representative survey in Nepal

Prajula Mulmi, William A. Masters*, Steven A. Block and Patrick Webb

* Corresponding author: william.masters@tufts.edu, phone +1.617.636.3751

Abstract

Children's dietary diversity, particularly their intake of more nutrient-dense food groups, is an important influence on nutritional status and health in low-income countries where malnutrition is most widespread. Previous studies in regions with low intake of nutritious foods have found diet quality to be positively associated with their household's own agricultural production, especially in remote settings far from markets. We add to this literature by identifying the mediating role of household wealth as a resource that can facilitate market access and purchase of foods to complement what households themselves can grow. We focus on a nationally-representative sample of Nepali children between 6-59 months surveyed in 2013 and again in 2014 (n=5,978 children), for whom we test links to dietary diversity from three measures of household agricultural production. Controlling for village fixed effects and other factors, we find that children in households that grow a larger number of food groups and food species have higher dietary diversity (p=0.05), but only among poorer households. Logit regressions are employed to assess mediating effects of wealth on links between child intake and household production of each individual food group. We find significant effects for fruits and vegetables, especially dark green leafy vegetables and vitamin-A rich fruits and vegetables, as well as eggs and dairy, but again in all cases this linkage holds only at lower levels of wealth. Raising livestock for meat is positively associated with child dietary diversity at all wealth levels, and children consume starchy staples and legumes regardless of their household production. Findings imply that home production interventions to improve child dietary intake are likely to be most effective if they target poorer farming households, particularly for eggs, dairy, dark green leafy vegetables, and vitamin-A rich fruits and vegetables.

Acknowledgements

This project was funded by the Feed the Future Innovation Lab for Nutrition (www.nutritioninnovationlab.org) under USAID grant contract AID-OAA-L-1-00005, with additional support for W.A. Masters from the Feed the Future Policy Research Consortium (http://ru-ftf.rutgers.edu), under USDA grant TA-CA-15-008. We are grateful to Shibani Ghosh, Liz Marino-Costello, Robin Shrestha and Grace Namirembe at Tufts, as well as Keith West, Rolf Klemm, and the entire Nutrition Innovation Lab for their support and assistance.

Keywords

Agricultural development; child nutrition; production diversity; dietary diversity; farm households

1. Introduction and motivation

The composition of children's dietary intake has long been a major concern in developing countries (Kant, 1996; Ruel, 2003), as lack of diversity among food groups has been shown to be associated with micronutrient deficiencies (Arimond and Ruel, 2004; Moursi et al., 2008). Rural farming families in developing countries are particularly vulnerable to poor dietary quality and low diversity (Bageant et al., 2016), in part because they lack access to markets to complement the foods they can grow on their own farms (Banerjee and Duflo, 2007; Nicholson and Snyder, 2008). In many settings, children in poor rural families consume mainly the starchy staples that are easiest to grow and most affordable to buy, typically tubers or cereal grains, with some leguminous grains such as groundnuts or lentils. Other nutrient-dense foods, such as fruits and vegetables rich in vitamin A, dairy, eggs, and meat, are more difficult to produce or exchange in the market and less frequently consumed (Kumar et al., 2015), so interventions to increase household production of these foods could potentially improve child nutrition (Herforth, 2010; Pandey et al., 2016; Webb, 2013; Webb and Kennedy, 2014).

This paper builds on Pandey et al. (2016), Darrouzet-Nardi et al. (2016) and Jones et al. (2014) to address linkages between farm production and dietary intake. Motivated by the recent literature on international nutrition (Gillespie et al., 2012; Haddad, 2000; Hawkes et al., 2011), several pathways have been posited through which a household's own farm activity could potentially impact child health including: 1) agricultural production for own consumption, 2) agricultural production as source of income for food and non-food purchases, 3) agricultural policies that affect food prices and choices, 4) decision-making among women in agriculture that influence intra-household allocation of food and resources, 5) time allocated for childcare and feeding practices for women engaged in the agricultural sector, and 6) effects of agricultural labor environment on maternal health and nutrition and its indirect effects on child nutrition outcomes. There is some evidence for all of these pathways (Bageant et al., 2016; Kadiyala et al., 2014; Malapit and Quisumbing, 2015; Pandey et al., 2016), but limited knowledge of specific mechanisms and effect modifiers that might guide targeting and design of interventions (Headey et al., 2012).

This study is motivated by economic models of farm households in which consumption decisions such as a children's dietary intake could be made separately from agricultural production decisions, if local markets were sufficiently accessible for sale and purchase of relevant products (de Janvry et al., 1991; Foster and Rosenzweig, 2010). With competitive markets, a household's agricultural production would affect their consumption decisions only through total resources, as household members' preferences and relative costs would then determine how they use those resources for consumption (de Janvry et al., 1991; Foster and Rosenzweig, 2010; Mendola, 2007). This kind of separability between production and consumption is typically observed only for households with access to competitive markets, however; in more remote settings, the production decisions of subsistence farmers are influenced more directly by their own consumption needs, and vice-versa as consumption is more closely linked to production opportunities (Eswaran and Kotwal, 1989). Our study builds on that literature by identifying the mediating effect of wealth, testing whether poorer households in a given village (and hence at a similar distance to markets) experience less separability, making their children's dietary intake more dependent on their own production.

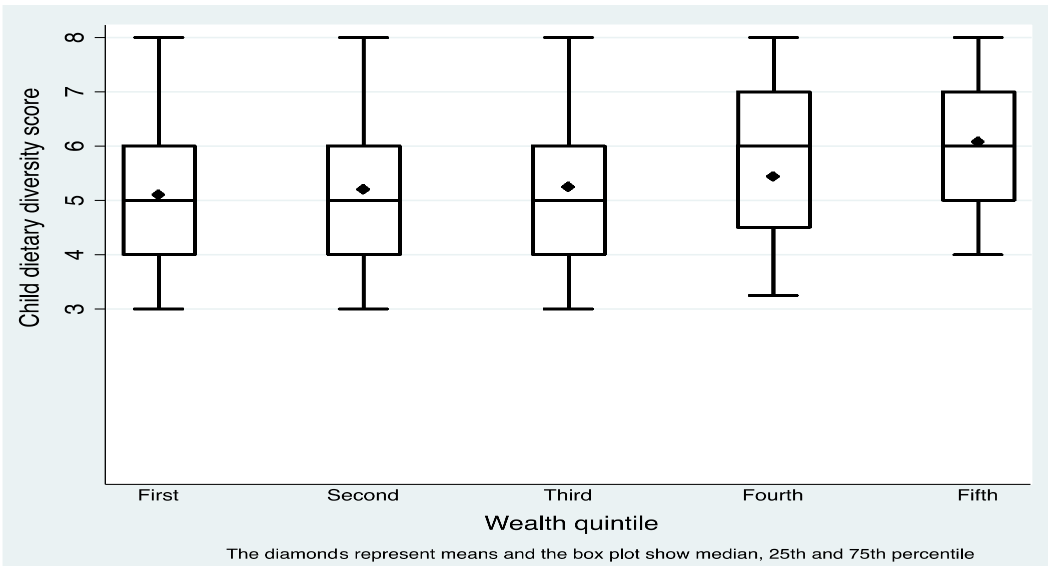
In the international nutrition literature, links between agriculture and diet quality are often tested using the association between dietary diversity and the diversity of farm production. Empirical studies commonly find a significant and positive correlation, despite small sample sizes (Herforth, 2010; Jones et al., 2014; Keding et al., 2012; Kumar et al., 2015), especially in African settings (Jones et al., 2014; Kumar et al., 2015; Ng'endo et al., 2016), and especially in more remote locations with less access to food markets (Sibhatu et al., 2015). Relatively few of these studies focus specifically on children's consumption in South Asian contexts (Kumar et al., 2015; Pandey et al., 2016), however, even though South Asian children may be especially vulnerable to poor outcomes (Shively and Sununtnasuk, 2015). Previous studies also focus primarily on how markets mediate the relationship between agricultural production and nutrition outcomes (Darrouzet-Nardi and Masters, 2015; Sibhatu et al., 2015). Here we control for physical access to markets using village fixed effects, and address household factors that influence the relationship between food production and consumption – specifically household wealth, which could provide economic access to whatever markets are physically available in each location. We also disaggregate dietary diversity and farm production diversity into specific food groups, so as to identify which foods have the least separability between production and consumption.

Farming practices of poorer households may differ from those of wealthier households in many ways, but a key factor is access to the cash and other resources needed to use markets rather than their own production. Previous research has focused primarily on richer households' ability to smooth outcomes over time, using cash and other resources to manage and cope with risks (IFAD, 2010). Because less wealthy and rural households in farming communities are more risk-averse in the face of uncertainties they are less efficient and persistently poor as compared to their wealthier counterparts (Duflo, 2006; Mendola, 2007). In this study we investigate a different use of cash and other resources, which is households' ability to complement their own farm production with foods purchased from the market.

Nepal provides an appropriate economic and socio-demographic context to test the mediating role of wealth in separating production and consumption decisions. Out of the country's 28.5 million people, 82% are rural (World Bank, 2015) and mainly grow cereals including rice, maize, wheat, millet, and barley with limited diversification into more nutrient-dense foods (WFP 2014). Agricultural conditions and market access are also extremely diverse across and within the Mountain, Hill, and Terai regions which are subjected to different agro-climatic conditions (Ministry of Health and Population et al., 2012) and are administratively subdivided into 75 districts and 3,915 Village Development Committee (VDCs) (Central Bureau of Statistics, 2014). And despite recent progress in reducing child under-nutrition (United Nations 2013), Nepal is marked at a "serious" level according to the Global Hunger Index (von Grebmer et al., 2016).

Micronutrient deficiencies are particularly widespread, as almost half of children under five (46%) are anemic, and 25% of children are deficient in Vitamin A (Ministry of Health and Population et al., 2012).

Figure 1. Child dietary diversity score by wealth quintile



Panel data, obtained from Policy and Science of Health, Agriculture and Nutrition (PoSHAN) Community Studies conducted in Nepal in 2013 and 2014, are used to investigate the study hypothesis. The preliminary analysis of the data suggests differences in child dietary diversity scores by household wealth status (Figure 1). Median dietary diversity score for children that fall within the first three wealth quintiles are lower by a unit as compared to households in the upper wealth quintile (5 vs.6). The main objectives of the study are 1) to quantify association between agricultural production diversity and child dietary diversity, and the mediating role of household wealth; 2) to quantify association between production of a food group and its consumption among children and the mediating role of household wealth.

2. Methods

2.1 Dataset and study variables

A detailed description of PoSHAN sampling strategy, dataset, and descriptive statistics of the analytic sample is described elsewhere (Mulmi 2017). The survey uses multistage stratified cluster sampling and 2011 census as a sampling frame to recruit households. Strata include three agro-ecological zones: Mountains, Hills and Terai, and clusters include seven Village Development Committee (VDCs) per ecological zone (Manohar et al., 2014). The analytic sample is a balanced panel (n= 2989 groups and 5,978 observations) comprising children between the ages of 6-59 months and their mothers. Caretakers other than mothers including grandmothers and fathers that make up a small subset of the sample (n=164) are excluded from the study.

The main outcome variable of the study is child dietary diversity score (CDDS), which is a discrete variable ranging from (1-8), and computed using FAO's guideline for individual dietary diversity. The nine FAO food groups include: (1) starchy staples; (2) Dark Green Leafy Vegetables (DGLVs); (3) vitamin A rich fruits and vegetables; (4) other fruits and vegetables; (5) meat and fish; (6) eggs; (7) dairy, (8) organ meat; and (9) legumes, nuts and seeds. The dietary survey lacks information on organ meat, and are hence excluded when computing CDDS (Kennedy et al., 2011). And the secondary outcome variable is whether children in the sample eat each of the eight individual food groups. Both the outcome variables are constructed from the seven-day food frequency questionnaires used in the PoSHAN survey as described in Mulmi (2017).

Agricultural production diversity is one of the predictor variables. Three measures of agricultural production diversity are constructed using crops grown and livestock raised annually. Those measures include 1) whether households are farmers or non-farmers; 2) a total number of food groups each households grow (0-8); and 3) agricultural diversity quintile (0-5). Food groups that households grow correspond to the eight FAO food groups mentioned above (Kennedy et al., 2011). Agricultural diversity quintile is determined for each child using a total number of crop and livestock species grown. Individual food group production is another predictor variable defined as whether households grow each of the eight FAO-food groups mentioned earlier.

Wealth quintile is a mediating variable of interest, which is constructed based on guidelines from the DHS and elsewhere (Rutstein, 2016; Vyas & Kumaranayake, 2006). Wealth quintile for each child's household is constructed using durable assets owned and economic information about the household such as total number of rooms available in a house, for example. Other confounding socio-demographic variables accounted for in the study include caste and ethnicity, religion, maternal education and BMI, maternal and child age, whether child was breastfed, and a total amount of land owned and rented. The inclusion of these control variables is justified elsewhere (Bennett, 2005; Bennett et al., 2008; Ministry of Health and Population et al., 2012; Pandey et al., 2013). It is notable that Dalits and Janajatis are amongst the poorest in Nepal. While the poverty rates declined for all caste groups between 1995 and 2004, the decline was modest with Terai Dalits and Janajatis (28%) as compared to upper caste Brahmin, Chhetris and Newars (46%) (The World Bank, 2006). Dalits, Janajatis and Terai castes also show more unfavorable health and nutrition outcomes than their higher caste counterparts.

2.2 Estimation Strategy

All analysis included in the study is done using Stata/SE, version 14. In order to quantify associations between agricultural production diversity and child dietary diversity, OLS regressions with village fixed effects are estimated using the following base specification:

$$CDDS_i = B_0 + B_1\, farm_{ih} + B_2\, wealth_{ih} + B_3\, farm_{ih}\ X\ wealth_{ih} + \delta\, Z_i + \alpha\, VDC_i + \gamma\, year + \mu_i \qquad (1)$$

$$CDDS_i = B_0 + B_1\, fgroup_{ih} + B_2\, wealth_{ih} + B_3\, fgroup_{ih}\ X\ wealth_{ih} + \delta\, Z_i + \alpha\, VDC_i + \gamma\, year + \mu_i \qquad (2)$$

$$CDDS_i = B_0 + B_1\, fquint_{ih} + B_2\, wealth_{ih} + B_3\, fquint_{ih}\ X\ wealth_{ih} + \delta\, Z_i + \alpha\, VDC_i + \gamma\, year + \mu_i \qquad (3)$$

where $CDDS_i$ indicates child dietary diversity score of a child aged 6-59 months, $farm_{ih}$ is a dummy variable equal to 1 when *h*=household of a child *i* produces any food and zero otherwise,

$fgroup_{ih}$ is a variable ranging from 0-8 indicating number of food groups produced by household *h* of child *i*, and $fquint_{ih}$ represents quintile of agricultural production diversity (0-5) of child *i* in household *h*.

We split the analytical sample by ecological zones before regressions are run through equations 1-3 to assess mediating effects of wealth on agricultural production diversity and child dietary diversity. Wealth quintile of each child *i* in household *h* is represented by B_2. Preliminary analysis indicates that wealth quintile, food group, and agricultural production diversity behave in a linear fashion. These variables are, hence, included in the models in a linear form. An interaction between main predictor variables and wealth are represented by B_3, which is the main coefficient of interest in quantifying mediating effects of wealth.

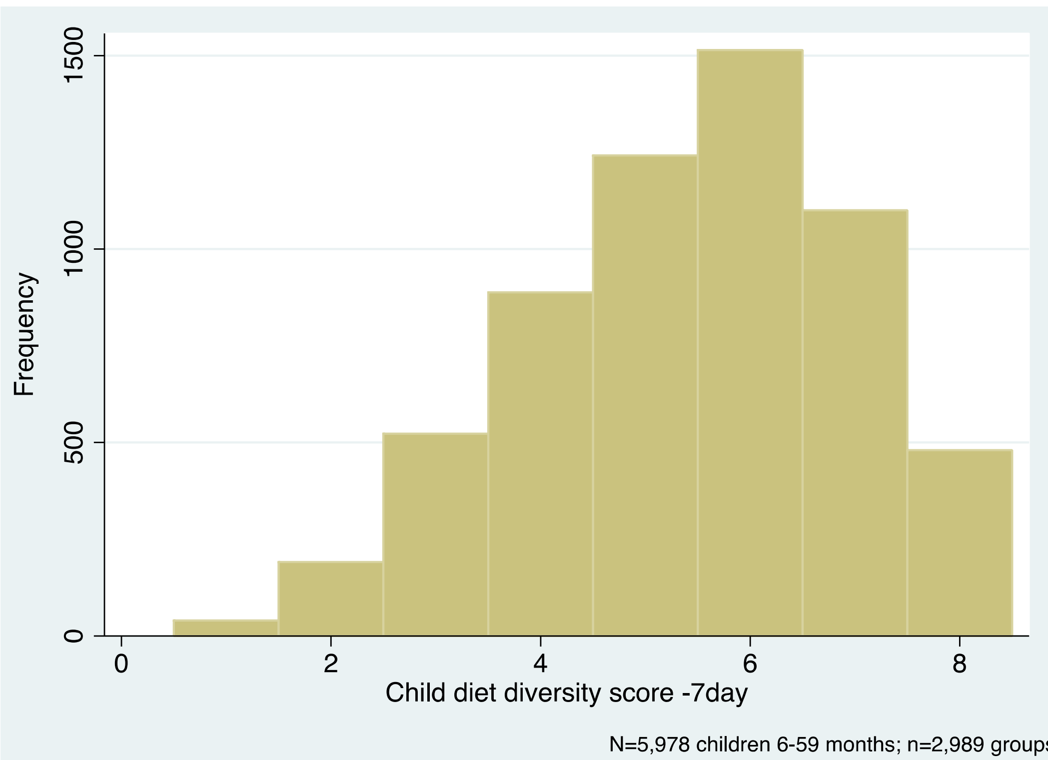
Z_i represents a vector of control variables at the child, household and VDC levels as shown in results (Tables 1-10). All the common determinants of child dietary intake are controlled for in the regressions (Lamichhane et al., 2016; Martorell et al., 1984). Quadratic forms of child age (in months) are included to account for the non-linear relationship between child age and child dietary diversity (WHO, 2001). Block (2006) showed that maternal nutritional knowledge substitutes maternal schooling in achieving better child nutrition outcomes. Hence, the regression model assumes and accounts for non-linear relationship between maternal schooling (in years) and child nutrition outcomes. All the OLS regressions above include VDC fixed effects and year fixed effects that account for temporal and geographical factors that do not change over time. For each child, *i*, the error term is represented by $\mu_{i.}$

Associations between individual food group production and consumption are assessed for each of the eight FAO food groups. For each individual food group, we split the analytical sample by ecological zones to account for climatic and topographic differences on agricultural production. Logit regression models are then run using the following base specification:

$Cnsmptn'_i = B_0 + B_1 prdctn'_{ih} + B_2 wealth_{ih} + B_3 prdctn_{ih}\ X\ wealth_{ih} + \delta Z_i + \alpha VDC_i + \gamma year + \mu_i$ (4)

The base specification is run for each of the eight FAO food groups separately, where $Cnsmptn'_i$ and $prdctn'_{ih}$ indicate binary variables. $Cnsmptn'_i$ indicates whether child *i* eats a food group and $prdctn'_{ih}$ represents whether household *h* of that child grows the same food group. B_3 shows coefficient of the interaction between a food group produced and wealth quintile of household *h* of a child *i*. The remainder of the notations and functional forms are the same as in equations 1-3.

Figure 2. Distribution of child dietary diversity scores (CDDS)



Count data such as the CDDS are often analyzed using Poisson models (Cano Fernández et al., 2009; Colin and Trivedi, 1986) or transformed for use with OLS methods (Cohen and Cohen, 2003), but as shown in Figure 2 the CDDS counts are already normally distributed and not truncated at zero (Long, 1997). As a result they can be used directly with OLS methods without violating the underlying assumption of using OLS models (Woolridge, 2013). The CDDS in PoSHAN dataset have a mean of 5.4, and has no observations at the zero lower bound, so can be used with OLS methods as if it were a continuous variable (Coxe et al., 2009; Grace-Martin, 2016; Plan, 2014). This provides more direct interpretation of results than would be possible with Poisson methods (Atkins and Gallop, 2007).

3. Results

Using OLS and controlling for variables at the child-, maternal-, and household-level, this study rejects the null hypothesis that there is no interaction between wealth and agricultural production diversity on CDDS (Tables 1-2). For both the tables, coefficients on interaction term are statistically significant at 5% level at the national, Mountain and Hill levels (columns 1-3). In Terai, the results are not statistically significant, but the coefficients are still negative.

Table 1. Child diet diversity score (CDDS) and number of food groups produced

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
Food group grown (0-8)	0.116**	0.298**	0.178**	0.123*
	(0.04)	(0.09)	(0.07)	(0.06)
Wealth quintile (1-5)	0.240**	0.717***	0.470**	0.219*
	(0.10)	(0.03)	(0.13)	(0.11)
Food group grown X Wealth quintile	-0.032**	-0.076**	-0.049**	-0.026
	(0.01)	(0.02)	(0.01)	(0.02)
Land rented/used (hectares)	-0.019*	0.003	-0.008	-0.067
	(0.01)	(0.02)	(0.01)	(0.09)
Land owned only (hectares)	0.001	-0.010	0.010	-0.074**
	(0.01)	(0.01)	(0.01)	(0.02)
Child's age (months)	0.127***	0.065**	0.105***	0.153***
	(0.01)	(0.02)	(0.02)	(0.01)
Child's age squared (months)	-0.002***	-0.001*	-0.001***	-0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.024	-0.087	-0.003	0.061**
	(0.03)	(0.10)	(0.06)	(0.02)
Whether breastfed	-0.008	0.174	-0.051	0.010
	(0.05)	(0.14)	(0.11)	(0.06)
Mother's age (years)	0.008*	-0.002	0.017*	0.002
	(0.00)	(0.02)	(0.01)	(0.00)
Mother's schooling (years)	0.036	0.020	0.103	-0.050
	(0.04)	(0.07)	(0.06)	(0.04)
Mother's schooling (squared)	-0.000	0.001	-0.005	0.005*
	(0.00)	(0.00)	(0.00)	(0.00)
Mother can read	0.114	0.206	0.013	0.285
	(0.14)	(0.22)	(0.27)	(0.16)
Mother's BMI (Kg/m^2)	0.026***	0.024	0.029**	0.022**
	(0.01)	(0.02)	(0.01)	(0.01)
Female head of household	-0.145***	-0.053	-0.244***	-0.022
	(0.04)	(0.16)	(0.03)	(0.05)
Excluded caste	-0.270***	-0.248	-0.231*	-0.160
	(0.08)	(0.31)	(0.11)	(0.13)
Non-Hindu	-0.005	-0.256	-0.074	0.131
	(0.09)	(0.21)	(0.15)	(0.12)
Year (2014)	-0.115	-0.038	-0.404**	-0.078
	(0.08)	(0.17)	(0.14)	(0.07)
Constant	0.454	-0.034	0.873	1.776***
	(0.34)	(0.74)	(0.75)	(0.30)
Observations	5,978	798	1,380	3,800
R-squared	0.305	0.214	0.393	0.221
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted OLS regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Food groups (1-8) grown correspond to eight food group categories adapted from the FAO's dietary diversity guidelines. Non-farming households (food group=0) are also included. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.
*** p<0.01, ** p<0.05, * p<0.1

Table 2. Child diet diversity score and quintile of food species produced

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
Ag. diversity quintile (0-5)	0.178**	0.537***	0.301**	0.188*
	(0.07)	(0.11)	(0.10)	(0.10)
Wealth quintile (1-5)	0.224**	0.771***	0.469***	0.209*
	(0.09)	(0.03)	(0.12)	(0.10)
Ag. diversity quintile X Wealth quintile	-0.046**	-0.129***	-0.075**	-0.039
	(0.02)	(0.03)	(0.02)	(0.03)
Land rented/used (hectares)	-0.020**	0.002	-0.009	-0.065
	(0.01)	(0.02)	(0.01)	(0.09)
Land owned only (hectares)	0.000	-0.011	0.009	-0.074**
	(0.01)	(0.01)	(0.01)	(0.03)
Child's age (months)	0.127***	0.065**	0.105***	0.153***
	(0.01)	(0.02)	(0.02)	(0.01)
Child's age squared (months)	-0.002***	-0.001*	-0.001***	-0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.024	-0.091	-0.010	0.065**
	(0.03)	(0.11)	(0.06)	(0.02)
Whether breastfed	-0.011	0.171	-0.055	0.006
	(0.05)	(0.14)	(0.11)	(0.05)
Mother's age (years)	0.008*	-0.002	0.017*	0.002
	(0.00)	(0.02)	(0.01)	(0.00)
Mother's schooling (years)	0.033	0.022	0.101	-0.052
	(0.04)	(0.07)	(0.06)	(0.04)
Mother's schooling (squared)	-0.000	0.001	-0.005	0.005*
	(0.00)	(0.00)	(0.00)	(0.00)
Mother can read	0.114	0.216	0.008	0.291
	(0.14)	(0.21)	(0.27)	(0.16)
Mother's BMI (Kg/m^2)	0.027***	0.023	0.030**	0.022**
	(0.01)	(0.02)	(0.01)	(0.01)
Female head of household	-0.138***	-0.059	-0.227***	-0.017
	(0.04)	(0.16)	(0.04)	(0.06)
Excluded castes	-0.259***	-0.233	-0.195	-0.163
	(0.08)	(0.32)	(0.10)	(0.13)
Non-Hindu	0.000	-0.261	-0.093	0.136
	(0.09)	(0.20)	(0.15)	(0.12)
Year (2014)	-0.115	-0.032	-0.413**	-0.076
	(0.08)	(0.17)	(0.14)	(0.07)
Constant	0.452	-0.370	0.748	1.839***
	(0.33)	(0.69)	(0.69)	(0.31)
Observations	5,978	798	1,380	3,800
R-squared	0.304	0.214	0.393	0.221
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted OLS regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Agricultural production diversity quintile (1-5) is generated from total count of food species (1-32) produced in a farming household; non-farmers (Agricultural production diversity quintile =0) are also included. Food species count is created from a sum of crop species (0-29) and livestock grown (0-6) per household. Range of food species count included in the quintile is as follows: First (1-2), Second (3-5), Third (6-9), Fourth (10-14), and Fifth (15-32). Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.
*** p<0.01, ** p<0.05, * p<0.1

To further illustrate the results, predictive margins for CDDS are plotted at each level of wealth for food groups (Figure 3) and agricultural diversity quintile (Figure 4). It is apparent from both the figures that agricultural production diversity is positively associated with dietary diversity only at lower levels of wealth but not at higher levels of wealth. For example, in the lowest wealth quintile, average CDDS is approximately 4.7 when households do not grow any food, and 5.4 when households grow all the eight food groups (Figure 3). However, at the highest level of wealth positive association between agricultural production diversity and CDDS no longer holds.

Figure 3. Predicted margins of CDDS from wealth & food group grown (all regions)

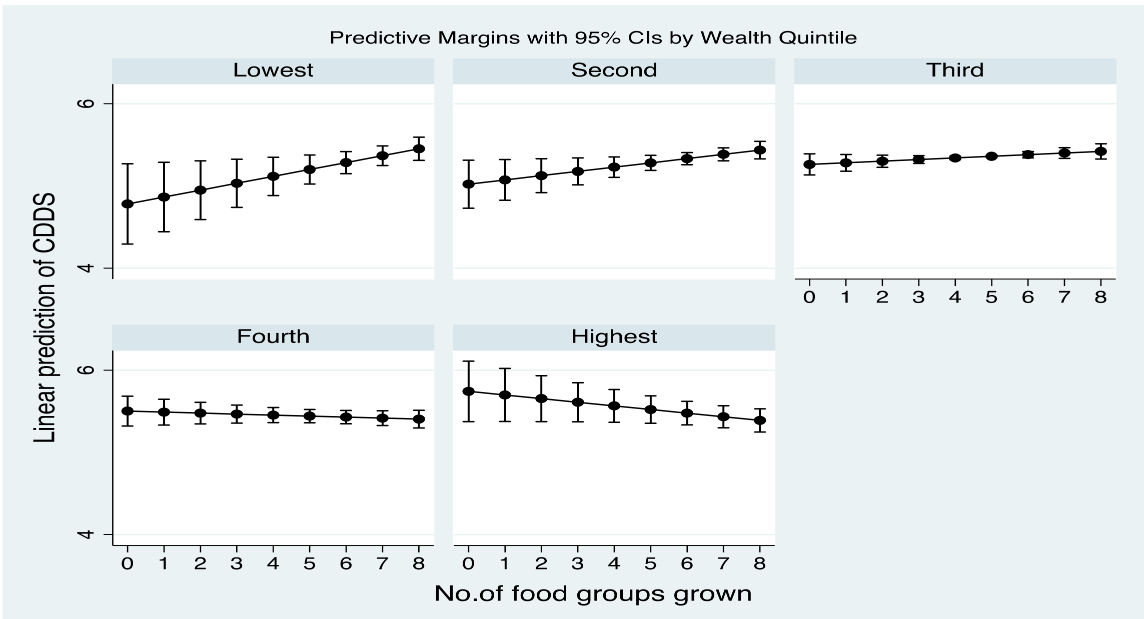
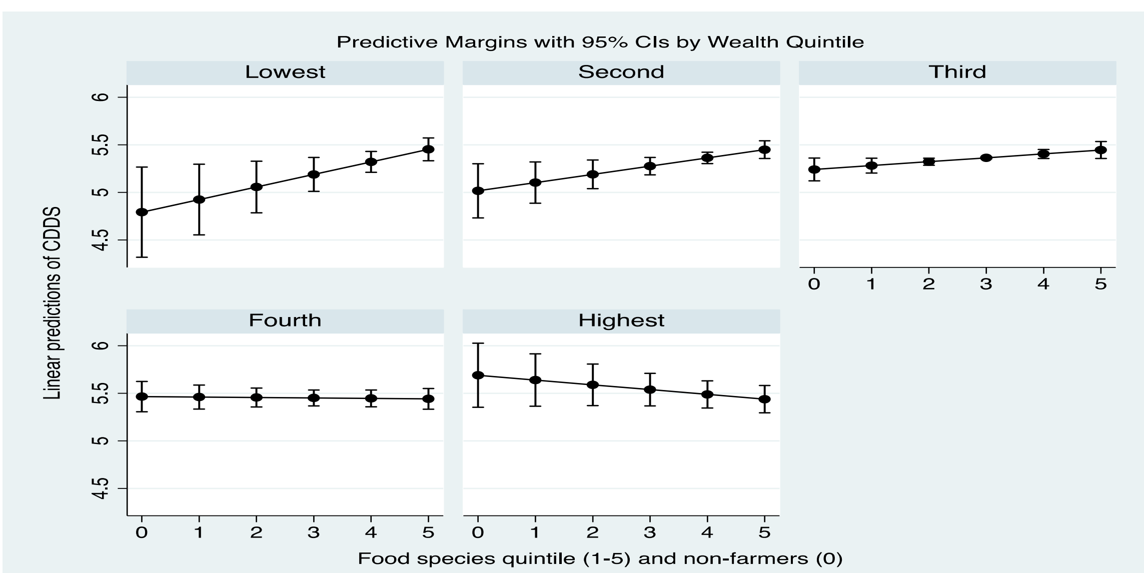


Figure 4. Predicted margins of CDDS from wealth & agricultural diversity quintile (all regions)



Wealth and agricultural production diversity are independently and positively associated with CDDS at standard levels of significance (Tables 1-2). For example, at the national level, all else equal using VDC and year fixed effects, this study finds that as the number of food groups grown increase by a unit CDDS increases by 0.12 units at 5% level of significance. Similarly, as wealth quintile of children living in a household increases by a unit CDDS increases by twice as much (0.24 units) at 5% level of significance (Table 1).

Table 3. Child dietary diversity score and farming status of the household

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
Household produces some farm output	0.401	0.655	-1.374*	0.348
	(0.25)	(0.92)	(0.60)	(0.31)
Wealth quintile (1-5)	0.228**	0.520**	-0.031	0.184
	(0.10)	(0.18)	(0.11)	(0.11)
Farming household X Wealth quintile	-0.136*	-0.182	0.191	-0.063
	(0.07)	(0.19)	(0.13)	(0.08)
Land rented/used (hectares)	-0.019*	-0.003	-0.008	-0.023
	(0.01)	(0.02)	(0.01)	(0.09)
Land owned only (hectares)	-0.000	-0.013*	0.009	-0.062**
	(0.01)	(0.01)	(0.01)	(0.02)
Child's age (months)	0.126***	0.065**	0.104***	0.153***
	(0.01)	(0.02)	(0.02)	(0.01)
Child's age squared (months)	-0.002***	-0.001*	-0.001***	-0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.024	-0.092	-0.001	0.064**
	(0.03)	(0.10)	(0.06)	(0.02)
Whether breastfed	-0.007	0.167	-0.068	0.022
	(0.05)	(0.14)	(0.11)	(0.05)
Mother's age (years)	0.009*	-0.002	0.019**	0.002
	(0.00)	(0.02)	(0.01)	(0.00)
Mother's schooling (years)	0.040	0.025	0.107	-0.041
	(0.04)	(0.07)	(0.06)	(0.04)
Mother's schooling (squared)	-0.001	0.001	-0.006	0.005
	(0.00)	(0.00)	(0.00)	(0.00)
Mother can read	0.118	0.212	0.011	0.281
	(0.14)	(0.22)	(0.26)	(0.16)
Mother's BMI (Kg/m^2)	0.027***	0.028	0.029**	0.022**
	(0.01)	(0.02)	(0.01)	(0.01)
Female head of household	-0.168***	-0.054	-0.276***	-0.053
	(0.04)	(0.16)	(0.04)	(0.04)
Excluded caste	-0.275***	-0.251	-0.266*	-0.161
	(0.08)	(0.32)	(0.12)	(0.13)
Non-Hindu	-0.009	-0.241	-0.073	0.133
	(0.09)	(0.21)	(0.16)	(0.15)
Year (2014)	-0.112	-0.014	-0.369**	-0.043
	(0.08)	(0.18)	(0.14)	(0.06)
Constant	0.632*	0.866**	3.362***	1.860***
	(0.36)	(0.27)	(0.54)	(0.37)
Observations	5,978	798	1,380	3,800
R-squared	0.302	0.205	0.392	0.216
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted OLS regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Farm households are dummy=1 if households produce any food and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu. *** p<0.01, ** p<0.05, * p<0.1

The above results are consistent only for farming households disaggregated by a total number of food groups and food species they produce. Results are inconsistent when farming households are treated as a homogenous group and compared against non-farming households (Table 3). For example, the coefficient on the interaction term is negative and significant (at 10% level) only at the national level. All the other zonal interaction terms (columns 2- 4) are neither significant nor consistent in direction.

In all the regression models (Tables 1-3), direction and statistical significance of other variables controlled for in the regression models, such as socially excluded caste groups, sex of head of households, and maternal- and child age, are consistent with prior studies (Bennett, 2005; DFID and The World Bank, 2006). Exclusion of lower caste and ethnic groups have shown to manifest itself in poorer economic, health, and nutrition outcomes as compared to outcomes in higher-caste counterparts, for example (Bennett et al., 2008; Pandey et al., 2013). Also, female-headed households are worse off in health and nutrition outcomes as compared to households headed by males. And nutrition outcomes tend to improve with increasing age of mothers and children (DFID and The World Bank, 2006).

Maternal BMI is consistently shown to be associated with maternal dietary diversity, birth outcomes and child anthropometrics but not child dietary diversity (Bhutta et al., 2013; Lartey, 2008; Rahman et al., 2015). In this case, however, maternal BMI is also shown to be positively and significantly associated with child dietary diversity. For example, when maternal BMI increases by 1 kg/m^2 the child dietary diversity score increases by 0.026 units ($p=0.01$), all else equal. The BMI effect we see is possibly mirroring wealth effect as others have shown that higher wealth levels are positively associated with both maternal BMI and child dietary diversity (Amugsi et al., 2016).

Variables such as maternal schooling and literacy and religion are typically associated with child dietary diversity (Block, 2006; Nguyen et al., 2013). However, coefficients on those variables either do not appear to be statistically significant or consistent across ecological zones. For example, previous studies show that a number of years mothers went to school is associated with better quality of diet among children (Amponsah et al., 2016; Block, 2006; Frost et al., 2005). But coefficients on maternal schooling are not statistically significant except for the quadratic term on schooling in Terai. Similarly, CDDS of Hindus is not significantly greater than those of non-Hindus. It is a surprising finding given consistent evidence from prior studies[1] that suggest marginalization of non-Hindus, particularly Muslims (Aasland & Haug, 2011; Bennett 2005; DFID and The World Bank 2006). Multi-collinearity partly explains inconsistencies in results among control variables, which does not bias coefficients but could enlarge standard errors (Woolridge, 2013).

Association between individual food group grown and its consumption among children are examined for seven out of the eight food groups (Tables 4-10). The coefficients on starchy staple could not be estimated, because there is no variation in its production and consumption, and are excluded. Among the seven food groups for which regression models are estimated at the national level, households that grow each of those food groups, except for meat and legumes, are more likely to have children that consume it as compared to households that do not grow them. All of these results hold for households only in the lower wealth quintile except for eggs, fruits and vegetables (Tables 4-10, col 1).

For the ecological zones, results across all the individual food groups are not consistent. But coefficients on the production of eggs and dairy appear to be consistently significant (Tables 8-9). For example, all else equal, households that raise egg-producing livestock have 3.87 higher log-odds of consuming it as compared to households without egg-producing livestock at 1% level of significance (Table 8, col 2). Similarly, in the Mountain, households that raise dairy-producing livestock have 2.61 higher log-odds of consuming it as compared to households without dairy-producing livestock (Table 9, col 2). All of these results hold only for poorer households. For all

[1] Immunization, under-five mortality and stunting rates are higher among Muslim and Dalit as compared to other caste groups and religious groups (Bennett et al., 2008; Pandey et al., 2013).

the other food groups, not all coefficients are statistically significant, but they are consistently positive across ecological zones except for meat consumption in the Mountain. And, at the national level, when households grow fruits and vegetables, they also have higher odds of entering children's diet but only in poorer households (Table 4 and 5).

Table 4. Child consumption and household production of dark green leafy vegetables

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces DGLVs	0.482***	0.993***	0.101	0.593**
	(0.18)	(0.36)	(0.38)	(0.24)
Wealth quintile	-0.013	0.158	-0.171	0.052
	(0.07)	(0.15)	(0.17)	(0.05)
Produces DGLVs X Wealth quintile	-0.104*	-0.152	0.002	-0.151**
	(0.05)	(0.16)	(0.12)	(0.06)
Land rented/used (hectares)	-0.035*	0.007	-0.021	0.254
	(0.02)	(0.05)	(0.02)	(0.16)
Land owned only (hectares)	-0.021**	-0.028**	-0.006	-0.145***
	(0.01)	(0.01)	(0.01)	(0.05)
Child's age (months)	0.114***	0.035	0.100***	0.138***
	(0.02)	(0.03)	(0.02)	(0.02)
Child's age squared (months)	-0.001***	-0.000	-0.001***	-0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	-0.017	-0.368***	-0.095	0.100
	(0.06)	(0.05)	(0.10)	(0.07)
Whether breastfed	0.155*	0.218	0.299	0.072
	(0.09)	(0.23)	(0.24)	(0.05)
Mother's age (years)	0.017***	0.020	0.029***	0.006
	(0.01)	(0.03)	(0.01)	(0.00)
Mother's schooling (years)	-0.057	-0.140**	0.005	-0.144***
	(0.05)	(0.06)	(0.08)	(0.04)
Mother's schooling (sq.)	0.007**	0.012***	0.003	0.013***
	(0.00)	(0.00)	(0.00)	(0.00)
Mother can read	0.392**	0.588***	0.321	0.575***
	(0.19)	(0.21)	(0.29)	(0.21)
Mother's BMI (Kg/m^2)	0.009	-0.008	0.006	0.007
	(0.01)	(0.03)	(0.01)	(0.01)
Female head of household	0.111	0.215	0.147	0.084
	(0.09)	(0.18)	(0.17)	(0.11)
Excluded castes	0.162	0.725*	0.345***	-0.448**
	(0.12)	(0.44)	(0.11)	(0.19)
Non-Hindu	-0.287***	-0.026	-0.399***	-0.899***
	(0.10)	(0.30)	(0.13)	(0.25)
Year (2014)	-0.168	-0.027	-0.574***	0.061
	(0.20)	(0.18)	(0.14)	(0.27)
Constant	-2.630***	-1.848***	-0.879	-1.963***
	(0.43)	(0.71)	(1.13)	(0.30)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Dark Green Leafy Vegetables (DGLVs) is a dummy=1 if households produce DGLVs and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Child consumption and household production of vitamin A rich fruits & vegetables

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces FVA	0.629**	2.384**	0.394	0.666**
	(0.27)	(0.94)	(0.69)	(0.27)
Wealth quintile	0.177*	0.848***	0.195	0.189*
	(0.10)	(0.30)	(0.16)	(0.11)
Produces FVA X Wealth quintile	-0.169**	-0.666***	-0.118	-0.113
	(0.08)	(0.19)	(0.15)	(0.09)
Land rented/used (hectares)	0.016	-0.086	0.032*	-0.038
	(0.02)	(0.07)	(0.02)	(0.13)
Land owned only (hectares)	-0.002	-0.021*	-0.001	0.002
	(0.01)	(0.01)	(0.00)	(0.04)
Child's age (months)	0.110***	0.097***	0.098***	0.120***
	(0.02)	(0.03)	(0.03)	(0.03)
Child's age squared (months)	-0.001***	-0.001**	-0.001***	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.119*	-0.044	0.327**	-0.002
	(0.07)	(0.07)	(0.14)	(0.10)
Whether breastfed	0.063	0.490*	0.085	0.002
	(0.07)	(0.25)	(0.11)	(0.09)
Mother's age (years)	0.006	-0.005	0.012	0.005
	(0.01)	(0.03)	(0.01)	(0.01)
Mother's schooling (years)	-0.011	-0.026	0.111	-0.137***
	(0.06)	(0.09)	(0.09)	(0.03)
Mother's schooling (sq.)	0.003	0.003	-0.005	0.009***
	(0.00)	(0.01)	(0.01)	(0.00)
Mother can read	-0.015	0.303	-0.291	0.341
	(0.19)	(0.26)	(0.42)	(0.22)
Mother's BMI (Kg/m^2)	0.002	0.075	0.021	-0.018
	(0.02)	(0.05)	(0.04)	(0.02)
Female head of household	-0.271***	0.146	-0.498***	-0.106*
	(0.08)	(0.29)	(0.09)	(0.06)
Excluded caste	-0.243	-1.316*	-0.331	0.339***
	(0.17)	(0.77)	(0.26)	(0.09)
Non-Hindu	0.165	0.043	0.238	0.726***
	(0.15)	(0.40)	(0.31)	(0.27)
Year (2014)	-0.230	-0.080	-0.379	-0.235
	(0.20)	(0.30)	(0.29)	(0.27)
Constant	-7.749***	-11.017***	-4.846***	-1.469***
	(0.50)	(1.68)	(0.78)	(0.52)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Fruits and vegetables rich in vitamin A (FVA) produced is a dummy=1 if households produce FVA and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.

*** p<0.01, ** p<0.05, * p<0.1

Table 6. Child consumption and household production of fruits and vegetables

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces FV	0.631*	1.345	0.894***	0.916**
	(0.33)	(1.49)	(0.24)	(0.44)
Wealth quintile	0.152	0.801***	0.501***	0.110
	(0.15)	(0.15)	(0.08)	(0.17)
Produces FV X Wealth quintile	-0.161	-0.411	-0.256***	-0.206
	(0.12)	(0.33)	(0.08)	(0.16)
Land rented/used (hectares)	0.022	-0.006	0.070**	0.100
	(0.03)	(0.06)	(0.04)	(0.19)
Land owned only (hectares)	0.019	0.001	0.047*	0.077
	(0.02)	(0.02)	(0.02)	(0.11)
Child's age (months)	0.176***	0.119***	0.099**	0.253***
	(0.03)	(0.02)	(0.04)	(0.02)
Child's age squared (months)	-0.002***	-0.002***	-0.001**	-0.003***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.091	-0.123	-0.122	0.411***
	(0.16)	(0.19)	(0.19)	(0.13)
Whether breastfed	0.103	-0.005	0.140	0.083
	(0.09)	(0.27)	(0.14)	(0.14)
Mother's age (years)	0.027***	-0.007	0.039***	0.028***
	(0.01)	(0.04)	(0.01)	(0.01)
Mother's schooling (years)	0.049	0.042	0.176*	-0.143**
	(0.07)	(0.07)	(0.11)	(0.07)
Mother's schooling (sq.)	0.001	0.001	-0.009	0.014**
	(0.01)	(0.00)	(0.01)	(0.01)
Mother can read	-0.082	-0.221	-0.060	0.126
	(0.20)	(0.30)	(0.31)	(0.35)
Mother's BMI (Kg/m^2)	0.019*	0.050	0.025	-0.008
	(0.01)	(0.04)	(0.02)	(0.01)
Female head of household	-0.063	0.000	-0.037	0.064
	(0.10)	(0.30)	(0.10)	(0.11)
Excluded caste	-0.287**	-0.684***	-0.094	-0.442**
	(0.12)	(0.25)	(0.12)	(0.18)
Non-Hindu	-0.451**	-0.328*	-0.547	-0.696***
	(0.22)	(0.19)	(0.45)	(0.26)
Year (2014)	-0.076	-0.484	-0.517*	-0.136
	(0.12)	(0.48)	(0.29)	(0.25)
Constant	-5.843***	-5.636***	-3.681***	-3.354***
	(0.51)	(1.45)	(0.66)	(0.38)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Fruits and vegetables (FVs) produced is a dummy=1 if households produce FVs and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Child consumption and household production of meat production

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces meat	0.189	-0.503	2.425***	0.116
	(0.16)	(1.06)	(0.84)	(0.16)
Wealth quintile	0.170***	0.271	0.821***	0.112***
	(0.06)	(0.18)	(0.25)	(0.04)
Produce meat X Wealth quintile	-0.079*	0.029	-0.532***	-0.040
	(0.04)	(0.26)	(0.20)	(0.05)
Land rented/used (hectares)	-0.037**	-0.027	-0.023	-0.146
	(0.02)	(0.04)	(0.02)	(0.10)
Land owned only (hectares)	0.011	-0.020	0.035***	-0.084
	(0.01)	(0.01)	(0.01)	(0.05)
Child’s age (months)	0.104***	0.046	0.102***	0.118***
	(0.01)	(0.04)	(0.02)	(0.01)
Child’s age squared (months)	-0.001***	-0.000	-0.001***	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	0.130***	-0.037	0.132	0.175***
	(0.04)	(0.07)	(0.12)	(0.04)
Whether breastfed	-0.101	0.117	-0.241	-0.017
	(0.08)	(0.11)	(0.20)	(0.07)
Mother’s age (years)	-0.007	0.006	-0.002	-0.012
	(0.01)	(0.01)	(0.01)	(0.01)
Mother’s schooling (years)	0.073	0.133***	0.070	0.042
	(0.06)	(0.04)	(0.11)	(0.09)
Mother’s schooling (sq.)	-0.007*	-0.009***	-0.009	-0.003
	(0.00)	(0.00)	(0.01)	(0.01)
Mother can read	0.036	0.155	0.096	0.022
	(0.23)	(0.31)	(0.45)	(0.29)
Mother’s BMI (Kg/m^2)	0.042***	-0.025	0.012	0.063***
	(0.01)	(0.02)	(0.02)	(0.01)
Female head of household	-0.236***	-0.332	-0.435***	-0.047
	(0.08)	(0.23)	(0.10)	(0.11)
Excluded caste	-0.137	0.076	0.133	-0.036
	(0.15)	(0.23)	(0.31)	(0.21)
Non-Hindu	0.512***	-0.322	-0.067	1.003***
	(0.20)	(0.49)	(0.27)	(0.25)
Year (2014)	-0.123	0.089	-0.684**	-0.020
	(0.11)	(0.19)	(0.30)	(0.09)
Constant	-3.302***	-1.576*	-3.898***	-3.047***
	(0.19)	(0.88)	(0.92)	(0.26)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Meat produced is a dummy=1 if households own meat-producing livestock and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Child consumption and household production of eggs

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces egg	1.064***	3.865***	1.865***	0.691**
	(0.27)	(0.86)	(0.43)	(0.28)
Wealth quintile	0.226***	0.624***	0.513***	0.183***
	(0.06)	(0.15)	(0.14)	(0.06)
Produce egg X Wealth quintile	-0.107	-0.748***	-0.353***	0.037
	(0.08)	(0.19)	(0.08)	(0.08)
Land rented (hectares)	-0.021**	0.040***	-0.020	-0.273
	(0.01)	(0.01)	(0.01)	(0.21)
Land owned (hectares)	-0.008	-0.025**	0.000	-0.212
	(0.01)	(0.01)	(0.01)	(0.20)
Child's age (months)	0.095***	0.022	0.104***	0.108***
	(0.01)	(0.04)	(0.02)	(0.01)
Child's age sq. (months)	-0.001***	-0.000	-0.002***	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	-0.063	0.099	0.018	-0.138
	(0.09)	(0.24)	(0.21)	(0.09)
Whether breastfed	-0.097	-0.209	-0.436***	0.180**
	(0.10)	(0.29)	(0.09)	(0.08)
Mother's age (years)	-0.001	-0.023*	0.004	0.002
	(0.01)	(0.01)	(0.03)	(0.01)
Mother's schooling (years)	0.039	-0.096	0.102	0.006
	(0.05)	(0.07)	(0.07)	(0.08)
Mother's schooling (sq.)	-0.002	0.006	-0.006	0.001
	(0.00)	(0.00)	(0.00)	(0.01)
Mother can read	0.124	0.668**	0.047	0.210
	(0.23)	(0.30)	(0.42)	(0.35)
Mother's BMI (Kg/m^2)	0.029***	0.063***	0.035	0.015*
	(0.01)	(0.02)	(0.02)	(0.01)
Female head of household	0.005	0.172	-0.300**	0.221
	(0.12)	(0.22)	(0.14)	(0.14)
Excluded castes	-0.392**	-0.141	-0.272	-0.249
	(0.16)	(0.50)	(0.26)	(0.26)
Non-Hindu	0.394***	-0.566**	0.224	0.741***
	(0.15)	(0.27)	(0.25)	(0.27)
Year (2014)	-0.119	0.391**	-0.347*	-0.212
	(0.09)	(0.19)	(0.18)	(0.16)
Constant	-4.869***	-5.867***	-4.959***	-4.474***
	(0.28)	(0.63)	(0.75)	(0.21)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Eggs produced is a dummy=1 if households own eggs-producing livestock and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.

*** p<0.01, ** p<0.05, * p<0.1

Table 9. Child consumption and household production of dairy

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces dairy	0.914***	2.611***	1.781***	0.707***
	(0.24)	(0.95)	(0.45)	(0.25)
Wealth quintile	0.329***	0.621***	0.505***	0.297***
	(0.06)	(0.08)	(0.14)	(0.06)
Produce dairy X Wealth quintile	-0.191**	-0.568**	-0.396**	-0.128*
	(0.08)	(0.25)	(0.17)	(0.08)
Land rented/used (hectares)	-0.020	0.067	-0.019	-0.133
	(0.02)	(0.04)	(0.02)	(0.12)
Land owned only (hectares)	0.006	0.026***	0.004	-0.011
	(0.01)	(0.01)	(0.01)	(0.05)
Child's age (months)	0.049***	0.034	0.034**	0.060***
	(0.01)	(0.04)	(0.02)	(0.02)
Child's age sq. (months)	-0.001***	-0.000	-0.000***	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	-0.106	0.058	-0.177	-0.100
	(0.08)	(0.14)	(0.14)	(0.12)
Whether breastfed	-0.193*	0.410*	-0.231*	-0.284*
	(0.11)	(0.22)	(0.12)	(0.15)
Mother's age (years)	0.004	-0.027	0.004	0.004
	(0.01)	(0.02)	(0.01)	(0.01)
Mother's schooling (years)	0.095***	0.112	0.109***	0.018
	(0.03)	(0.20)	(0.03)	(0.05)
Mother's schooling (sq.)	-0.002	-0.002	-0.004	0.006
	(0.00)	(0.01)	(0.00)	(0.01)
Mother can read	0.089	-0.515*	-0.042	0.300**
	(0.14)	(0.26)	(0.26)	(0.13)
Mother's BMI (Kg/m^2)	0.044***	-0.017	0.072***	0.036***
	(0.01)	(0.03)	(0.03)	(0.01)
Female head of household	-0.278***	-0.498***	-0.248***	-0.281***
	(0.05)	(0.11)	(0.09)	(0.07)
Excluded caste	-0.550***	-0.483**	-1.050***	-0.028
	(0.20)	(0.19)	(0.23)	(0.33)
Non-Hindu	-0.475**	0.475***	0.053	-0.442*
	(0.24)	(0.18)	(0.29)	(0.24)
Year (2014)	-0.054	-0.219	-0.087	-0.048
	(0.09)	(0.19)	(0.15)	(0.15)
Constant	-1.379***	-0.820	-3.686***	-1.984***
	(0.43)	(0.96)	(1.12)	(0.49)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Dairy produced is a dummy=1 if households own dairy-producing livestock and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.

*** p<0.01, ** p<0.05, * p<0.1

Table 10. Child consumption and household production of legumes

	(1) All regions	(2) Mountains	(3) Hills	(4) Terai
HH produces legumes	0.352	1.331	0.479	0.301
	(0.37)	(1.93)	(0.57)	(0.66)
Wealth quintile	0.362***	0.359	0.604***	0.264***
	(0.10)	(0.45)	(0.23)	(0.08)
Produce legumes X Wealth quintile	-0.103	-0.255	-0.247	0.030
	(0.15)	(0.53)	(0.22)	(0.23)
Land rented/used (hectares)	-0.037	-0.037	-0.028	0.005
	(0.02)	(0.08)	(0.03)	(0.47)
Land owned only (hectares)	0.033	0.439**	0.039	0.052
	(0.02)	(0.22)	(0.03)	(0.13)
Child's age (months)	0.126***	0.034	0.121**	0.145***
	(0.03)	(0.06)	(0.05)	(0.02)
Child's age sq. (months)	-0.002***	-0.000	-0.002**	-0.002***
	(0.00)	(0.00)	(0.00)	(0.00)
Child (female)	-0.087	-0.053	-0.262*	0.155
	(0.10)	(0.29)	(0.15)	(0.15)
Whether breastfed	0.100	-0.265	-0.032	0.281
	(0.19)	(0.37)	(0.32)	(0.21)
Mother's age (years)	0.018*	0.030	0.033**	-0.003
	(0.01)	(0.05)	(0.01)	(0.02)
Mother's schooling (years)	-0.062	0.053	-0.025	-0.176
	(0.13)	(0.28)	(0.18)	(0.19)
Mother's schooling (sq.)	0.008	-0.002	0.007	0.013
	(0.01)	(0.02)	(0.01)	(0.02)
Mother can read	0.281	0.851	0.065	0.665*
	(0.46)	(0.65)	(0.71)	(0.39)
Mother's BMI (Kg/m^2)	0.019	0.060	0.008	0.025
	(0.03)	(0.09)	(0.05)	(0.04)
Female head of household	-0.243	0.629***	-0.188	-0.490**
	(0.17)	(0.19)	(0.25)	(0.24)
Excluded caste	-0.274	-1.004**	-0.348	-0.270
	(0.24)	(0.40)	(0.30)	(0.31)
Non-Hindu	-0.279	-0.547	-0.099	-0.538***
	(0.41)	(0.67)	(0.61)	(0.17)
Year (2014)	0.026	0.154	-0.200	0.101
	(0.18)	(0.73)	(0.31)	(0.34)
Constant	-1.039	-1.437	-2.451*	-1.050
	(0.90)	(2.20)	(1.44)	(0.73)
Observations	5,978	798	1,380	3,800
VDC FE	Yes	Yes	Yes	Yes

Notes. Unit of observation is an individual child between 6-59 months. Standard errors in parentheses, clustered on VDCs. All results are from weighted logit regressions with fixed effects for each of 21 VDCs and 2 years. Survey weights are used for children in the balanced panel. The weights are 0.537 for Mountain, 1.711 for Hill and 0.834 for Terai. Description of variables: Legumes produced is a dummy=1 if households produce and 0 otherwise. Whether breastfed is dummy=1 if children were breastfed in the past seven days and 0 otherwise. Excluded castes are dummy=1 if Dalit, Janajati and other Terai caste and 0 otherwise. Non-Hindu are dummy=1 if a household is non-Hindu and 0 if Hindu.
*** p<0.01, ** p<0.05, * p<0.1

4. Conclusions and discussions

This study finds that child dietary diversity and intake of nutrient-dense foods in Nepal is associated with their household's farm production diversity and production of those foods, but only for poorer households. The non-separability observed among poorer households is specific to child intake of dark green leafy vegetables, vitamin-A rich fruits and vegetables, eggs, and dairy. Almost all children eat starchy staples and legumes regardless of whether households produce them.

These findings complement prior research such as Sibhatu et al. (2015), implying that agricultural interventions to improve child dietary diversity can be effective if they target production of these foods among poorer farming households. While some social protection programs aim to target poorer smallholder households (Devereux, 2016), the poorest groups are also the most difficult to target and reach (Altaf, 2016). The findings, hence, emphasize the need to identify mechanisms for increasing program coverage and targeting amongst the ultra-poor in low-income settings; Targeting the Ultra-Poor Program (TUP) in Bangladesh, for example, could be a useful model for other resource-poor settings (Brac, 2016).

Our findings regarding dark green leafy vegetables and vitamin-A-rich fruits and vegetables are particularly applicable for children at risk of vitamin A deficiency. Among animal-sourced foods, our results for egg- and dairy-producing livestock are consistent with other findings from Nepal (Bageant et al., 2016; Darrouzet-Nardi et al., 2016) and results from program evaluations elsewhere (Kafle et al., 2016; Rawlins et al., 2014), and the difference between them is notable: two-thirds of surveyed households engage in dairy production while only one-third participate in egg production, perhaps due to differences in feed and veterinary care requirements.

The findings from this study use nationally-representative data that are generalizable across Nepal, and also potentially relevant to other low-income settings with programmatic and policy implications. Methodologically, an important contribution of this study is precise definition and practical measurement of agricultural production diversity, first for relevance to nutritional attributes of each crop and livestock species by aggregating them into the food groups used to measure dietary diversity, and then for relevance to agro-ecological diversity by dividing the sample into quintiles by the number of different species produced.

One limitation of the study is that statistical controls are limited to village and year fixed effects. Future studies with other data could use additional techniques to address the possibility of omitted variable biases, including possible mediating roles of relevant socio-demographic factors such as households' caste and ethnicity. Future work could also aim to identify how wealthier households use their assets to achieve separability between production and consumption, and identify the most cost-effective techniques to help poorer households improve their children's diet quality through either home production or market access.

References

Altaf, A., 2016. Synthesis report. Defining, targeting, and reaching the very poor: Bangladesh, Benin and Ethiopia (ASC working paper 130/2016). University of Amsterdam and African Studies Centre Leiden.

Amponsah, E.N., Yiadom, L.B., Agyemang, M., 2016. The effect of maternal education on child health: some evidence from Ghana. Int. J. Econ. Bus. Res. 11, 366. doi:10.1504/IJEBR.2016.077027

Amugsi, D.A., Dimbuene, Z.T., Bakibinga, P., Kimani-Murage, E.W., Haregu, T.N., Mberu, B., 2016. Dietary diversity, socioeconomic status and maternal body mass index (BMI): quantile regression analysis of nationally representative data from Ghana, Namibia and Sao Tome and Principe. BMJ Open 6, e012615. doi:10.1136/bmjopen-2016-012615

Arimond, M., Ruel, M.T., 2004. Dietary diversity is associated with child nutritional status: evidence from 11 Demographic and Health Surveys. J. Nutr. 134, 2579–2585.

Atkins, D.C., Gallop, R.J., 2007. Rethinking how family researchers model infrequent outcomes: A tutorial on count regression and zero-inflated models. J. Fam. Psychol. 21, 726–735. doi:10.1037/0893-3200.21.4.726

Azzarri, C., Zezza, A., Haile, B., Cross, E., 2015. Does Livestock Ownership Affect Animal Source Foods Consumption and Child Nutritional Status? Evidence from Rural Uganda. J. Dev. Stud. 51, 1034–1059. doi:10.1080/00220388.2015.1018905

Bageant, E., Liu, Y., Diao, X., 2016. Agriculture-nutrition linkages and child health in the presence of conflict in Nepal (IFPRI Discussion Paper No. 01515), Markets, Trade and Institutions Division and Development Strategy and Governance Division. IFPRI.

Banerjee, A., Esther, D., 2007. The economic lives of the poor. J. Econ. Perspect. 21, 141–167.

Bennett, L., 2005. Gender, caste and ethnic exclusion in Nepal: Following the policy process from analysis to action, in: New Frontiers of Social Policy. Presented at the Arusha Conference.

Bennett, L., Dahal, D.R., Govindasamy, P., 2008. Caste, ethnic and regional identity in Nepal: Further analysis of the 2006 Nepal Demographic and Health Survey. Macro International Inc., Calverton, Maryland, USA.

Bhutta, Z.A., Das, J.K., Rizvi, A., Gaffey, M.F., Walker, N., Horton, S., Webb, P., Lartey, A., Black, R.E., 2013. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? The Lancet 382, 452–477. doi:10.1016/S0140-6736(13)60996-4

Block, S.A., 2006. Maternal nutrition knowledge versus schooling as determinants of child micronutrient status. Oxf. Econ. Pap. 59, 330–353. doi:10.1093/oep/gpm001

Brac, 2016. Ultra-poor programme [WWW Document]. URL http://www.brac.net/tup#who_we_are

Cano Fernández, V.J., Guirao Pérez, G., Rodríguez Donate, M.C., Romero Rodríguez, M.E., 2009. An analysis of count data models for the study of exclusivity in wine consumption. Appl. Econ. 41, 1563–1574. doi:10.1080/00036840601032227

Central Bureau of Statistics, 2014. Population monograph of Nepal. (No. Volume II), Population dynamics. Government of Nepal, National Planning Comission Secretariat.

Cohen, J., Cohen, J. (Eds.), 2003. Applied multiple regression/correlation analysis for the behavioral sciences, 3rd ed. ed. L. Erlbaum Associates, Mahwah, N.J.

Colin, C.A., Trivedi, P.K., 1986. Econometric models based on count data: comparisons and application. J. Appl. Econom. 1.

Coxe, S., West, S.G., Aiken, L.S., 2009. The Analysis of Count Data: A Gentle Introduction to Poisson Regression and Its Alternatives. J. Pers. Assess. 91, 121–136. doi:10.1080/00223890802634175

Darrouzet-Nardi, A.F., Masters, W.A., 2015. Urbanization, market development and malnutrition in farm households: evidence from the Demographic and Health Surveys, 1986–2011. Food Secur. 7, 521–533. doi:10.1007/s12571-015-0470-9

Darrouzet-Nardi, A.F., Miller, L.C., Joshi, N., Mahato, S., Lohani, M., Rogers, B.L., 2016. Child dietary quality in rural Nepal: Effectiveness of a community-level development intervention. Food Policy 61, 185–197. doi:10.1016/j.foodpol.2016.03.007

de Janvry, A., Fafchamps, M., Sadoulet, E., 1991. Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained. Econ. J. 101, 1400. doi:10.2307/2234892

Devereux, S., 2016. Social protection for enhanced food security in sub-Saharan Africa. Food Policy 60, 52–62. doi:10.1016/j.foodpol.2015.03.009

DFID, The World Bank, 2006. Unequal citizens: gender, caste and ethnic exclusion in Nepal. World Bank, Kathmandu.

Duflo, E., 2006. Poor but rational? in: Understanding Poverty. Oxford University.

Eswaran, M., Kotwal, A., 1989. Credit as insurance in agrarian economies. J. Dev. Econ. 31, 37–53.

Foster, A.D., Rosenzweig, M.R., 2010. Microeconomics of Technology Adoption. Annu. Rev. Econ. 2, 395–424. doi:10.1146/annurev.economics.102308.124433

Frost, M.B., Forste, R., Haas, D.W., 2005. Maternal education and child nutritional status in Bolivia: finding the links. Soc. Sci. Med. 60, 395–407. doi:10.1016/j.socscimed.2004.05.010

Gillespie, S., Harris, J., Kadiyala, S., 2012. The agriculture-nutrition disconnect in India: What do we know?, in: IFPRI Discussion Paper 1187. International Food Policy Research Institute (IFPRI), Washington, D.C.

Grace-Martin, K., 2016. The analysis factor. Can Count Data Be Consid. Contin.

Haddad, L.J., 2000. A conceptual framework for assessing agriculture-nutrition linkages. Food Nutr. Bull. 21, 367–373.

Hawkes, C., Arimond, M., Ruel, M.T., Sifri, Z., Berti, P.R., Leroy, J.L., Low, J.W., Brown, L.R., Frongillo, E.A., 2011. From agriculture to nutrition: pathways, synergies and outcomes, in: Combating Micronutrient Deficiencies: Food-Based Approaches. CABI, pp. 41–75.

Headey, D., Chiu, A., Kadiyala, S., 2012. Agriculture's role in the Indian enigma: help or hindrance to the crisis of undernutrition? Food Secur. 4, 87–102. doi:10.1007/s12571-011-0161-0

Herforth, A., 2010. Promotion of traditional African vegetables in Kenya and Tanzania: A case study of an intervention representing emerging imperatives in global nutrition. Cornell University, Ithaca, N.Y.

IFAD, 2010. Rural poverty report 2011: new realities, new challenges : new opportunities for tomorrow's generation. International Fund for Agricultural Development, Rome, Italy.

Jones, A.D., Shrinivas, A., Bezner-Kerr, R., 2014. Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy 46, 1–12. doi:10.1016/j.foodpol.2014.02.001

Kadiyala, S., Harris, J., Headey, D., Yosef, S., Gillespie, S., 2014. Agriculture and nutrition in India: mapping evidence to pathways: Agriculture-nutrition pathways in India. Ann. N. Y. Acad. Sci. 1331, 43–56. doi:10.1111/nyas.12477

Kafle, K., Winter-Nelson, A., Goldsmith, P., 2016. Does 25 cents more per day make a difference? The impact of livestock transfer and development in rural Zambia. Food Policy 63, 62–72. doi:10.1016/j.foodpol.2016.07.001

Kant, A.K., 1996. Indexes of Overall Diet Quality. J. Am. Diet. Assoc. 96, 785–791. doi:10.1016/S0002-8223(96)00217-9

Keding, G.B., Msuya, J.M., Maass, B.L., Krawinkel, M.B., 2012. Relating dietary diversity and food variety scores to vegetable production and socio-economic status of women in rural Tanzania. Food Secur. 4, 129–140. doi:10.1007/s12571-011-0163-y

Kennedy, G., Ballard, T., Dop, M.C., European Union, 2011. Guidelines for measuring household and individual dietary diversity. Food and Agriculture Organization of the United Nations, Rome.

Kumar, N., Harris, J., Rawat, R., 2015. If They Grow It, Will They Eat and Grow? Evidence from Zambia on Agricultural Diversity and Child Undernutrition. J. Dev. Stud. 51, 1060–1077. doi:10.1080/00220388.2015.1018901

Lamichhane, D.K., Leem, J.H., Kim, H.C., Park, M.S., Lee, J.Y., Moon, S.H., Ko, J.K., 2016. Association of infant and young child feeding practices with under-nutrition: evidence from the Nepal Demographic and Health Survey. Paediatr. Int. Child Health 36, 260–269. doi:10.1080/20469047.2015.1109281

Lartey, A., 2008. Maternal and child nutrition in Sub-Saharan Africa: challenges and interventions. Proc. Nutr. Soc. 67, 105–108. doi:10.1017/S0029665108006083

Long, S.J., 1997. Regression models for categorical and limited dependent variables. Sage Publications Inc., Thousand Oaks, California.

Malapit, H.J.L., Quisumbing, A.R., 2015. What dimensions of women's empowerment in agriculture matter for nutrition in Ghana? Food Policy 52, 54–63. doi:10.1016/j.foodpol.2015.02.003

Manohar, S., Klemm, R., Rajbhandary, R., Adhikari, R., Gauchan, D., Shrestha, K., Webb, P., Ghosh, S., West, K.P.W., 2014. PoSHAN Community Studies Baseline Report. Nutrition Innovation Lab, Johns Hopkins University, Baltimore, MD.

Martorell, R., Leslie, J., Moock, P., 1984. Characteristics and determinants of child nutritional status in Nepal. Am. Soc. Clin. Nutr. 39, 74–86.

Mendola, M., 2007. Farm household production theories: a review of institutional and behavioral responses. Asian Dev. Rev. 24.

Ministry of Health and Population, New Era, ICF International Inc, 2012. Nepal Demographic and Health Survey 2011. Kathmandu, Nepal.

Moursi, M.M., Arimond, M., Dewey, K.G., Treche, S., Ruel, M.T., Delpeuch, F., 2008. Dietary Diversity Is a Good Predictor of the Micronutrient Density of the Diet of 6- to 23-Month-Old Children in Madagascar. J. Nutr. 138, 2448–2453. doi:10.3945/jn.108.093971

Mulmi, Prajula, 2017. Agriculture, Climate and Child Nutrition in Nepal. Doctoral dissertation, Tufts University, Friedman School of Nutrition Science and Policy.

Ng'endo, M., Bhagwat, S., Keding, G.B., 2016. Influence of Seasonal On-Farm Diversity on Dietary Diversity: A Case Study of Smallholder Farming Households in Western Kenya. Ecol. Food Nutr. 55, 403–427. doi:10.1080/03670244.2016.1200037

Nguyen, P.H., Avula, R., Ruel, M.T., Saha, K.K., Ali, D., Tran, L.M., Frongillo, E.A., Menon, P., Rawat, R., 2013. Maternal and Child Dietary Diversity Are Associated in Bangladesh, Vietnam, and Ethiopia. J. Nutr. 143, 1176–1183. doi:10.3945/jn.112.172247

Nicholson, W., Snyder, C., 2008. Microeconomic theory: basic principles and extensions, 10. ed. ed. Thomson South-Western, Mason, Ohio.

Pandey, J.P., Dhakal, M.R., Karki, S., Poudel, P., Pradhan, M.S., 2013. Maternal and child health in Nepal: the effects of caste, ethnicity, and regional identity., Further analysis of 2011 Nepal and Demographic Health Survey. Nepal Ministry of Health and Population, New Era, and ICF International, Calverton, Maryland, USA.

Pandey, V.L., Mahendra Dev, S., Jayachandran, U., 2016. Impact of agricultural interventions on the nutritional status in South Asia: A review. Food Policy 62, 28–40. doi:10.1016/j.foodpol.2016.05.002

Plan, E.L., 2014. Modeling and Simulation of Count Data. CPT Pharmacomet. Syst Pharmacol 3, e129. doi:10.1038/psp.2014.27

Rahman, M.M., Abe, S.K., Kanda, M., Narita, S., Rahman, M.S., Bilano, V., Ota, E., Gilmour, S., Shibuya, K., 2015. Maternal body mass index and risk of birth and maternal health outcomes in low- and middle-income countries: a systematic review and meta-analysis: Body mass index and pregnancy and health outcomes. Obes. Rev. 16, 758–770. doi:10.1111/obr.12293

Rawlins, R., Pimkina, S., Barrett, C.B., Pedersen, S., Wydick, B., 2014. Got milk? The impact of Heifer International's livestock donation programs in Rwanda on nutritional outcomes. Food Policy 44, 202–213. doi:10.1016/j.foodpol.2013.12.003

Ruel, M., 2003. Operationalizing dietary diversity: a review of measurement issues and research priorities. J. Nutr. 133, 3911S–3926S.

Rutstein, S.O., 2016. Steps to constructing the new DHS Wealth Index.

Shively, G., Sununtnasuk, C., 2015. Agricultural Diversity and Child Stunting in Nepal. J. Dev. Stud. 51, 1078–1096. doi:10.1080/00220388.2015.1018900

Sibhatu, K.T., Krishna, V.V., Qaim, M., 2015. Farm production diversity and dietary diversity in developing countries. Presented at the 2015 Agricultural and Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Franciso, CA.

The World Bank, 2006. Nepal resilience amidst conflict. An assessment of poverty in Nepal, 1995-96 and 2003-04 (No. 34834–NP).

von Grebmer, K., Bernstein, jill, Nabarro, D., Prasai, N., Amin, S., Yohannes, Y., Sonntag, A., Patterson, F., Towey, O., Thompson, J., 2016. 2016 Global hunger index: Getting to zero hunger. International Food Policy Research Institute, Washington, DC.

Vyas, S., Kumaranayake, L., 2006. Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plan. 21, 459–468. doi:10.1093/heapol/czl029

Webb, P., 2013. Impact pathways from agricultural research to improved nutrition and health: literature analysis and research priorities. Rome: Food and Agricultural Organization and Geneva: World Health Organization.

Webb, P., Kennedy, E., 2014. Impacts of Agriculture on Nutrition: Nature of the Evidence and Research Gaps. Food Nutr. Bull. 35, 126–132. doi:10.1177/156482651403500113

WHO, 2001. Complementary feeding: report of the global consultation., Summary of guiding principles for complementary feeding of the breastfed child. World Health Organization, Geneva.

Woolridge, J.M., 2013. Introductory Econometrics. A Modern Approach., Fourth. ed. Cengage Learning India Private Limnited, Delhi, India.

World Bank, 2015. World Bank Indicators.