Longitudinal analysis of the intrahousehold distribution of foods in rural Nepal: Effectiveness of a community-level development intervention

A.F. Darrouzet-Nardi*
Assistant Professor, Allegheny College, Meadville, PA
(adarrouzetnardi@allegheny.edu)

L.C. Miller
Professor, Tufts University School of Medicine, Boston, MA

N. Joshi
Heifer International Nepal, Katmandu, Nepal

S. Mahato
Heifer International Nepal, Katmandu, Nepal

M. Lohani
Heifer International, Little Rock, AK, USA

J. Drozdowsky
B.S. Candidate, Allegheny College, Meadville, PA

B.L. Rogers
Professor, Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA

Selected Paper prepared for presentation at the
2016 Agricultural & Applied Economics Association Annual Meeting
Boston, MA, July 31-August 2, 2016

*Corresponding author: 520 N. Main Street, Box E, Meadville, PA 16335 | Ph. 814-332-2793

Longitudinal analysis of the intrahousehold distribution of foods in rural Nepal: Effectiveness of a community-level development intervention

This version: 23 May 2016

Abstract: Inadequate child dietary quality is a problem of public health significance in rural Nepal. This study explores whether and how dietary patterns within households changed over a four-year time period with the introduction of a randomized community development intervention in rural Nepal. Individual-level dietary data within households is rarely observed over extended periods of time, which limits our understanding of within-household food distribution dynamics, especially in the context of impact evaluations. Six rural communities of Nepal with predominantly agricultural livelihoods were selected to participate in the phased implementation of a long-term community-level development intervention. Households (N=414 at baseline) and children (N=951 at baseline) in each community were surveyed at baseline; and the 116-item follow-up surveys were implemented at 6 months, 12 months, 18 months, 24 months, and 48 months. Detailed data on food consumption were collected at the household-level and for individual children older than 6 months of age using a 24 hour recall for 17 foods and food groups; parents responded for children. Child-level dietary diversity and consumption of animal sourced foods were the outcomes of interest. Fixed-effects analysis of the resulting panel data indicates that there are disparities in the responsiveness of child dietary quality with respect to household dietary quality, as measured by elasticities. Results indicate that there are no differences in the responsiveness of child dietary quality to household dietary quality between girl and boy children, but there are measurable disparities in dietary quality responsiveness across age groups of children and across regions of Nepal. As the length of time of exposure to the community development intervention increased, so did the responsiveness of child dietary quality to household dietary quality, as measured by elasticities. This pattern holds during both times of household stress and times of household prosperity, as indicated by the household-level dietary diversity differenced from the mean across all six time periods. The long-term, community-level development of rural women's groups may have increased women's status in the study sites and resulted in the improved diets for children, but measurement of women's status over time is necessary to test that hypothesis. These results stress the importance of measuring and addressing intrahousehold dynamics – in particular across age cohorts – during community development projects, and caution against assuming the presence of sex bias in the distribution of foods within households.

Acknowledgements: The authors acknowledge and are grateful to all the families who participated in the *Heifer* intervention in Nepal, all *Heifer* field staff, Preeti Subbha, Deepak Thapa, Nepal Technical Assistance Group (NTAG) field enumerators and office staff, and Dr. Rupa Singh of the B.P. Koirala Institute of Health Sciences in, Dharan, Nepal.

1. INTRODUCTION AND MOTIVATION

All development programs and projects around the world aim to improve well-being in some way, such as through increased health, wealth, or knowledge. These programs must operate not only in the context of diverse cultures, societies, and environments, but often also within complex intrahousehold resource allocation processes. The issue of intrahousehold dynamics is particularly relevant for those concerned with improving dietary quality and nutritional status. Food is typically a shared household resource, and different individuals within households have diverse calorie and micronutrient needs, depending primarily on life-stage, disease status, and calorie expenditure. The dynamics of household decision-making are a key factor determining the success of failure of community development interventions (Rogers 1990). Household resources may be inequitably distributed across different household members, but unequal distributions are not necessarily inequitable distributions, given wide ranging caloric and micronutrient needs. Individual-level dietary data within households is rarely observed over extended periods of time, which limits our understanding of within-household food distribution dynamics, especially in the context of impact evaluations. In general, impact evaluations could benefit from an increased focus on mechanisms of action.

With these issues in mind, this study explores whether and how dietary patterns within households changed over a four-year time period with the introduction of a randomized community-level development intervention in rural Nepal. Community development interventions – especially those focused on agriculture – have great potential to improve child dietary quality in rural households (Ruel and Alderman 2013). Although nutrition is improving in Nepal, inadequate child dietary quality is a problem of public health significance. Findings from the 2011 *Demographic and Health Survey* (DHS) in Nepal indicate that, for children aged 6 to 24 months in the 24-hours preceding the survey, only 28% of children were given foods from at least 4 different food groups, 46% of children consumed a food rich in vitamin A, and 24% of children consumed a food rich in iron (MOHP & ICF International 2012). Approximately 85 percent of the population in Nepal lives in rural areas (MOHP & ICF International 2012). After the 2015 earthquake in Nepal, 1.4 million people were labeled as food insecure, and the World Food Program (WFP) saw evidence of an extreme lack of food in 80 percent of households (WFP 2015). Approximately 35 percent of households were also practicing coping mechanisms such as limited meal portions and reduced number of meals (WFP 2015). Especially in this post-emergency context, it’s important to evaluate the effectiveness of local Non-Governmental Organizations (NGOs) with local experience and knowledge, at improving conditions.

The intervention examined here consists of a long-term program of participatory community-level development activities led by *Heifer International* (henceforth *Heifer)* field staff, specifically tailored for the situation in rural Nepal (Heifer International Nepal 2014). *Heifer* is a globally active NGO with over 300 projects in thirty-two countries. *Heifer* activities focus on the distribution of livestock and training to rural women's groups. The organization uses the introduction of livestock and related animal husbandry training as tools for poverty alleviation, citizen empowerment, and economic development. Given diverse local contexts and cultures, the impacts of community development interventions on improving child diets are difficult generalize across different populations. Women's status is a potential key mechanism through which community development interventions can improve child diets (Carletto et al. 2015). The *Heifer* intervention focuses on establishing local women's *Self-Help Groups* within communities, which met regularly to engage women in addressing agricultural, animal husbandry, and socioeconomic issues. We expect that this long-term training may have made the distribution of quality diets within the household more equitable, perhaps especially for animal sourced foods, as livestock were a particular focus of the intervention. This intervention has been demonstrated to improve both child health and dietary quality, but these results may vary across different regions and versions of the intervention (Miller et al. 2014; Darrouzet-Nardi et al. 2016; Rawlins et al. 2014). Impacts of the *Heifer* program on intrahousehold food allocation patterns have not been yet established.

2. BACKGROUND

2.1 Intrahousehold food allocation

Many studies examining intrahousehold food distribution dynamics have been concerned with the presence of sex bias. For example, a study in Bangladesh found that female children were nutritionally discriminated against, as evidenced by 16 percent higher calorie consumption among boy children compared with girl children under age 5 (Chen 1981). However, other studies have also found evidence that contradicts gender bias against girls. There may have been sex bias against girl children in Bangladesh, but it appears to be decreasing over time (Trapp et al. 2004). This sex bias may have been related to a lack of maternal empowerment (Trapp et al. 2004). In Nepal, there was evidence for sex bias against adult women, but not against girl children (Gittelsohn 1991). In Peru, there is some evidence for calorie bias against toddler aged children, but no differences across the sexes in the same population (Graham 1997). Some studies examine inequitable distributions in food quantities, which may miss the important aspect of dietary qualities (Messer 1997). For example, even though women in Nepal were consuming sufficient calories, they were still deficient in some key micronutrients, a pattern which may have resulted from cultural norms in which women of reproductive age may avoid fruits and vegetables (Messer 1997). Expectations that calorie expenditure of girl children is lower because their activity level is expected to be lower may also affect the distribution of foods within the household (Messer 1997).

2.2 Dietary diversity

To measure these dietary patterns within households, we must utilize a well-established indicator of dietary quality. Dietary quality is often measured by dietary diversity, which is a count of the number of food groups from which an individual had consumed. Dietary diversity is a direct determinant of nutritional status, especially for key micronutrients such as vitamin A and iron, which are found predominantly in animal sourced foods (Arimond et al. 2010; Arimond and Ruel 2004). Dietary diversity was found to be associated with child nutritional status, independent of associations with income and socioeconomic status in a wide range of settings (Arimond and Ruel 2004). One of the most well-established empirical findings in food consumption data over time and across countries is that the elasticity of dietary diversity with respect to favorable transfers is positive (Behrman and Deolalikar 1989). Thus, the diversity of people's diets tends to increase as income increases.

2.3 The role of women's status

The nature in which these favorable transfers are made may matter for the dietary outcomes. For example, previous evidence demonstrates that if adult women control the household resource in question, consumption patterns which favor children follow (Rogers 1996: Jin and Iannotti 2014). In South Asia in general, decisions about child caretaking and health-related matters usually fall to the woman (Kabeer 1999). Maternal age and education – potential proxies of empowerment – are significant determinants of child nutritional status Senegal, Bangladesh, and elsewhere (Linnemayr et al. 2008; Trapp et al. 2004; Hill and Upchurch 1995). Thus, the improvement of women's social standing could lead to improved child dietary outcomes, potentially through an improved distribution of food within the household. In light of this evidence, there are now many development projects which have an explicit focus on increasing women's empowerment. For example, microfinance interventions were effective in increasing women's empowerment, but not more effective than other types of interventions (Kabeer 2005). In Nepal specifically, women's land and livestock ownership was associated with their empowerment, and this empowerment was associated with their children's health (Allendorf 2007).

2.4 Community development for improved child diets

There are four broad potential pathways through which nutrition-sensitive agricultural activities such as *Heifer* programming can improve child diets and nutritional outcomes, as synthesized by Carletto et al. (2015): food prices, income from agriculture, consumption of own production, and gender-related issues. The latter mechanism relates directly to the design of the *Heifer* intervention, which focused on developing and facilitating women's *Self-Help Groups*. Increasing women's empowerment with a nearby community-level development intervention could result in an outward shift of the demand curve for children's food. Thus, we examine how the distribution of foods within the household changed in the context of a long-term community development intervention. It's important to ascertain the nature of these different responses to the *Heifer* intervention, as it could relate to outside factors, household factors, or individual factors, including the intrahousehold food distribution dynamics.

A long history of work in the applied economics, anthropology, sociology, nutrition, and public health literature have examined the intrahousehold distributions of various resources, particularly across the sexes (Belachew et al. 2011). In the context of East Africa, Villa et al. (2011) found mixed evidence of inequitable dietary quality within households, and cautioned that the presence or absence of dietary quality disparities shouldn't be assumed *a priori*. Villa et al. (2011) also establish that dietary quality responses to changes in income and prices are not symmetric across different levels of incomes and prices. The mediating effects of women's empowerment or time allocation on diets within the household is complex, as demonstrated recently in Ghana by Malapit et al. (2015a) and in Nepal by Malapit et al. (2015b), who found that some indicators of infant and young child feeding and maternal nutrition were associated with indicators of women's empowerment, though others were not.

2.5 Details of the intervention

The intervention consisted of a 12-month long program of participatory community-level development activities led by *Heifer* field staff (Heifer International Nepal 2014). The *Heifer* training curriculum focuses on poverty alleviation, citizen empowerment, and community development, with a strong emphasis on optimization of livestock management. These training activities are based in women's *Self-Help Groups* which meet biweekly with a trained facilitator. These meetings are supplemented by specific interactive instruction, workshops, guidance, and training. Over the course of approximately 12 months, the Heifer program is designed to promote community cohesion and self-reliance. The training is based on the "12 Cornerstones" for holistic community development. Each "Cornerstone" has specific training modules devised to encourage community accountability and participation via sharing resources, using sustainable agricultural practices, improving animal management, increasing household income, encouraging gender awareness, and planning for the future (Heifer International Nepal 2014). At the conclusion of the first year of involvement in these activities, two meat-type goats were donated to participating households, with the proviso that these first recipients "Pass on the Gift" to their neighbors, as a way to strengthen community bonds over time. This process and other details about the intervention can be found in Rawlins et al. (2014), Miller et al. (2014), and Darrouzet-Nardi et al. (2016). The *Heifer* training curriculum does not specifically address child diets, nutrition, or health.

2.6 Hypotheses

This central hypothesis of this study is that the intrahousehold allocation of foods in rural Nepal may differ across different demographic and geographic cohorts. We also expect that intrahousehold distributions of dietary quality became more equitable over a four-year time period with the introduction of a community-level development intervention which focused on women's empowerment through *Self-Help Groups*. For women who had been exposed to the intervention for longer periods of time, we expect that they would be better able – whether through increased knowledge, increased household resources, or increased power over household resources – to improve the distribution of foods within the household, when compared with women who had not been exposed to the intervention for as long a period of time.

3. METHODS

3.1 Study Design and Participants

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the *Nepal Health Research Council* (NHRC Reference #845, Renewal #1496), the human investigation review board in Nepal endorsed by the Office of Protection Office for Human Research Protections, U.S. Department of Health and Human Services, as well as the Tufts University *Institutional Review Board*. Parents gave permission for the inclusion of their children in the study. The study was located in three study sites of Nepal, in the districts of Chitwan, Nawalparasi, and Nuwakot. Chitwan and Nawalparasi are both located in the Terai region of Nepal; Nuwakot is located in the Hills. These areas are largely populated by low-income subsistence farmers. *Heifer* field activities are provided to specific areas at the request of local NGOs within rural communities. Three pairs of comparable interested communities in each of the three districts were identified, based on geographic location, altitude, size, local natural resources, employment opportunities, availability of health care, type of agriculture practiced, and other demographic features such as predominant castes, income and educational levels.

After the study sites were selected, a matched pair of communities was selected within each of the three study sites, and randomly assigned to receive *Heifer* development activities in a staggered intervention design, either first (Group 1) or second (Group 2), one year later. Thus, Group 1 participated in *Heifer* activities beginning immediately after the baseline survey; these activities continued through the entire 24 months, while Group 2 participated in *Heifer* activities beginning after 12 months; these activities continued from 12 to 24 months. In each community, *Heifer International* attempted to include all households for participation in the intervention, and participation rates exceeded 90% of households in each study site. All participating households were included in the sample for the baseline survey (N=431 households). All members of each participating household were enrolled in the study. Households and children in each community were surveyed at baseline, and follow-up surveys were implemented at 6 months, 12 months, 18 months, 24 months, and 48 months, for a total of six time points for survey enumeration.

3.2 Measuring child dietary quality

Diets and health of children age 6 months to 8 years who resided in participating households were assessed in detail as part of the study. Children < 6 months of age were excluded as they were likely to be completely breastfed (MOHP & ICF International 2012). The dietary intake questionnaire was an individual 24 hour recall for each child between 6 months and 8 years of age in the household. Household dietary quality was also measured. Other large-scale studies in South Asia have used 24 hour recall data to estimate dietary diversity data (Arimond et al. 2010). Recent evidence comparing biomarkers with different dietary recall instruments indicates that 24 hour recalls and other simple indicators perform relatively well (Prentice et al. 2011: Arimond et al. 2010). Consumption of additional foods such as animal sourced foods (ASF) which are typically rare in the diet in this setting can signal that the household can occasionally afford them. While frequent consumption of animal source foods and other healthy foods is important, occasional consumption in this setting is nutritionally meaningful, especially due to the low dietary quality at baseline. Further details of the original study design and data collection process can be found in Miller et al. (2014) and Darrouzet-Nardi et al. (2016).

There are two outcomes of interest for this study. The first outcome of interest is child dietary quality, as indicated by dietary diversity and animal sourced foods consumption for children under age 13. A dietary diversity score (DDS) was calculated from seventeen foods in the original questionnaire, aggregated into seven groups (WHO 2010). These seven food groups were: starchy staples (grains and white potatoes); vitamin-A rich fruits and vegetables; other fruits and vegetables; organ meat, meat, and fish; eggs; legumes, nuts, and seeds; milk and dairy products (WHO 2010). The second outcome of interest was an indicator of animal source foods consumption (ASF). This variable was constructed to be equal to the sum of each of the binary indicators for organ meat, meat, fish, eggs, milk, and dairy products alone.

3.3 Analysis

The exploratory model in Equation 1 below estimates the associations between child dietary quality and various determinants of child health. $Ln(Diet_{ihrt}^{c})$ represents two main child-level dietary quality outcomes of interest: the natural logarithms dietary diversity from all foods and from animal sourced foods. For our current empirical purposes, the models presented are in reduced-form demand function for child dietary quality; α_i is a constant intercept term; β^j represents the coefficients to be estimated on household-level characteristics including land holdings (m^2), livestock herd size (FAO animal score), mother's education levels at baseline (categorical), and annual income (H_{hrt}); β^k represents the coefficients to be estimated on child-level characteristics (C_{it}), including age (continuous, in months) and sex (binary); β_l represents the coefficient to be estimated on the binary variable indicating region ($Terai_r$); β_m represents the coefficient on the categorical variable indicating the years that a child has been exposed to the intervention ($Treatment_{it}$); and μ_{ihrt}^{c} is an independently and identically distributed error term. The estimation of this model, Equation 1 below, is presented in Columns 1 and 3 of Table 3 for child DDS and ASF outcomes, respectively.

$$Ln(Diet_{ihrt}^{c}) = \alpha_i + \sum_{j=1}^{J} \beta^j H_{hrt} + \sum_{k=1}^{K} \beta^k C_{it} + \beta_l Terai_r + \beta_m Treatment_{it} + \mu_{ihrt}^{c} \qquad (1)$$

Equation 2 below incorporates a difference-in-differences estimate of the effects of the intervention across the four-year study period , as well as child-level fixed-effects, denoted as α_i^c . Individual-level fixed-effects are important to include in order to address any time-invariant, individual-level factors which influence the elasticity of child dietary quality (Behrman and Deolalikar 1990). The $Period_t$ variable is a binary indicator of Period 1 (*P=0 = "before"*) and Period 2 (P=1=*"after"*) of the intervention. The coefficient to be estimated β_p represents the average treatment effect on the treated (ATET) of the intervention. All other notation is as previously described for Equation 1. The estimation of Equation 2 is presented below in Columns 2 and 4 of Table 3 for Child DDS and ASF outcomes, respectively.

$$Ln(Diet^{c}_{ihrt}) = \alpha^{c}_{i} + \sum_{j=1}^{J} \beta^{j} H_{hrt} + \sum_{k=1}^{K} \beta^{k} C_{it} + \beta_l Terai_r + \beta_m Treatment_{it} + \beta_n Period_t \quad (2)$$
$$\ldots + \beta_p \left(Treat_{it} * Period_t\right) + \mu^{c}_{ihrt}$$

Equations 1 and 2 are primarily for exploratory purposes. We are interested in estimating a reduced-form of demand for child dietary diversity with respect to household dietary diversity. We are also interested in whether the responsiveness of child dietary quality was different across key demographic and geographic groupings, or with respect to the length of time that each child was exposed to the intervention. To examine this, we estimate elasticities of child dietary quality with respect to household dietary quality using the model below. In the partial log-log form Equation 3 below, $\ln(HHDiet)_{hrt}$ represents the natural logarithms of the household-level dietary diversity score or animal source foods score for each time period, t=1 through 6. This term is interacted with various sub-groupings of the study population, represented by W_{ihrt}, including by sex (boy children and girl children), age group (6-24 months, 25-48 months, 49-72 months, >72 months), length of time exposed to the intervention (0, 1, 2, or 3 years), and region (Terai or Hills). β_k is the coefficient to be estimated on the variable indicating child age in months, Age_{it}, β_l is the coefficient to be estimated on the time trend *t*, included to capture any time-variant factors which are not included in the child-level fixed effects (α^{c}_{i}). To test our hypotheses regarding the intrahousehold allocation of foods over time, we will use Wald Tests to ask whether the β^{j} coefficients differ across key groupings of the study population (Wald 1945). Similar to Villa et al. (2011), these models are estimated across W_{ihrt} cohort groupings as a whole (Columns 1 & 4 of Tables 4 through 7 below), and then again separately for both favorable (prosperity) and unfavorable (stress) draws on household-level dietary quality (Villa et al. 2011). We did not aim to test for asymmetry itself in child dietary diversity response as in Villa et al. (2011). Instead, we were interested in whether there were disparities across cohorts during times of prosperity compared with times of stress. This estimation strategy was motivated by the strong seasonal patterns seen in these dietary data in previous work (Darrouzet-Nardi et al. 2016), as well as the asymmetry in dietary responses demonstrated in East Africa by Villa et al. (2011). Thus, we expect that household-level dietary quality varies across seasons, and that the responsiveness of child dietary quality to household dietary quality may differ depending on whether the household is experiencing times of prosperity ("harvest" season) or times of stress ("hungry" season). We stratify the elasticity estimates and test for differences in coefficients across different demographic and geographic cohorts.

$$Ln(Diet^{c}_{ihrt}) = \alpha^{c}_{i} + \sum_{j=1}^{J} \beta^{j} \left[\ln(HHDiet)_{hrt} * W_{ihrt} \right] + \beta_{k} Age_{it} + \beta_{l} t + \mu^{c}_{ihrt} \quad (3)$$

Following Villa et al. (2011), we can test for disparities in the responsiveness of child dietary diversity across various cohorts with the following hypothesis test:

$H_{o} : \beta^{j}_{1} = \beta^{j}_{2} ... = \beta^{j}_{J} \ \forall$ J $\in (1,...J)$, where J is the number of W_{ihrt} cohorts. (4)

H_{A} : At least one $\beta^{j}_{1} \neq \beta^{j}_{2}$ for some J $\in (1,...J)$.

The hypothesis test outlined above in Equation (4) will be stratified into two categories, for "harvest" and "hungry" seasons (Tables 4 through 7). These seasons are defined on a household-level basis: whether the household-level dietary diversity was above or below the mean across the four-year time period. This strategy mirrors what Villa et al. (2011) constructed for indicating favorable and unfavorable income draws over time to assess whether dietary responses were asymmetric across favorable and unfavorable draws.

$$H_{ht} = \begin{cases} 1 \ \ if \ \ HouseholdDDS_{ht} \geq \overline{HouseholdDDS_{h}} & = "Harvest" \\ 0 \ \ if \ \ HouseholdDDS_{ht} \leq \overline{HouseholdDDS_{h}} & = "Hungry" \end{cases} \quad (5)$$

4. RESULTS

The panel data resulting from the four years of data collection were analyzed using Stata/MP version 14.0 (StataCorp 2015). First, household-level descriptive statistics of the sample at baseline are presented below in Table 1. The average herd size was 2.91 at baseline. On average, households were achieving minimum dietary diversity, which is defined as having consumed foods from at least four different food groups. There is a wide range in land holdings and in annual income for the study population. Many households – 29% for Nepal as a whole (World Bank 2012) – were receiving foreign remittances as a substantial part of their incomes.

Table 1: Household descriptive statistics at baseline

Variable *N=414 total households*	Mean	Standard Deviation	Minimum	Maximum
Income (Nepali rupees per year)	68,627	47,868	3	8
Animal Score (GLU)	2.91	1.76	0	7.75
Land (m^2)	3,821	4,512	128	33,900
Household DDS (count)	4.45	0.957	3	8
Household ASF (count)	0.625	0.649	0	3

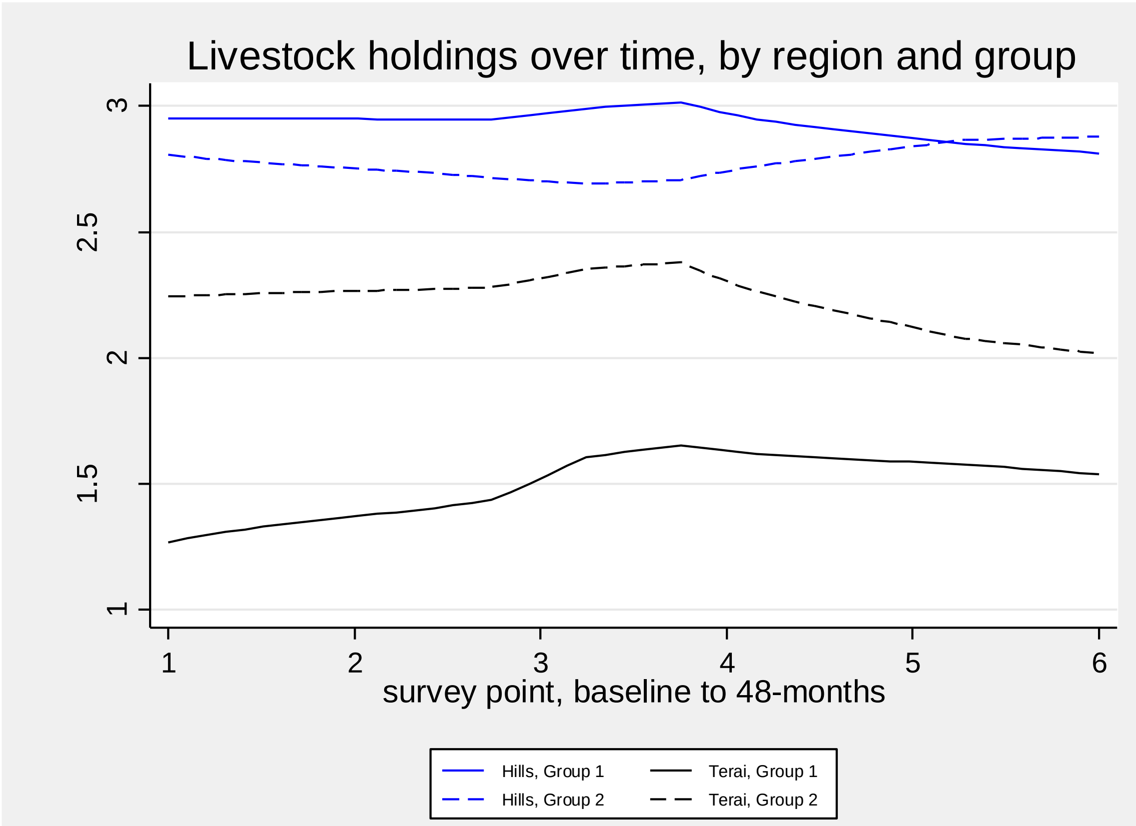
Notes: Animal scores are measured in Global Livestock Units (FAO 2013).

Figure 1 below outlines household-level livestock holdings over time. Data on individual livestock types were not enumerated during the 48-month visit, only aggregated animal scores are provided, hence the steep drop-off in livestock holdings at the 48-month point.

Figure 1: Livestock holdings over time

Figure 1 provides an outline of livestock ownership data, aggregated into animal scores (FAO 2013). Households in the Hills region had more substantial herds throughout the 4-year study period, but were relatively steady. Households across all four cohorts represented here experienced relatively steady herd sizes over the four year time period. The solid lines indicate those communities which had received the intervention starting after baseline measurements ("Group 1), and the dotted lines indicate communities which had received the intervention starting at t==3, the 12-month point (Group 2). Blue lines indicate communities located in the Hills, and black lines indicate communities located in the Terai. Notably, communities in the Terai had lower animal scores at baseline and then throughout the study period. One might expect a livestock-transfer program such as Heifer to have caused noticeable increases in the number of livestock per household in each community, yet this is not what we see. Instead, these patterns suggest that livestock herd sizes remained relatively steady throughout the study period.

Figure 1: Livestock holdings over time



Notes: Group 1 received the intervention starting after baseline (t=1), and group 2 received the intervention starting at the 12-month point (*t=3)*.

Table 2 below outlines child dietary data at baseline. T-tests for differences across sex and age groups suggest that there are no obvious disparities in DDS or ASF at baseline. Further detail on household and child dietary characteristics at baseline can be found in Darrouzet-Nardi et al. (2016).

Table 2: Child characteristics at baseline, by age and sex

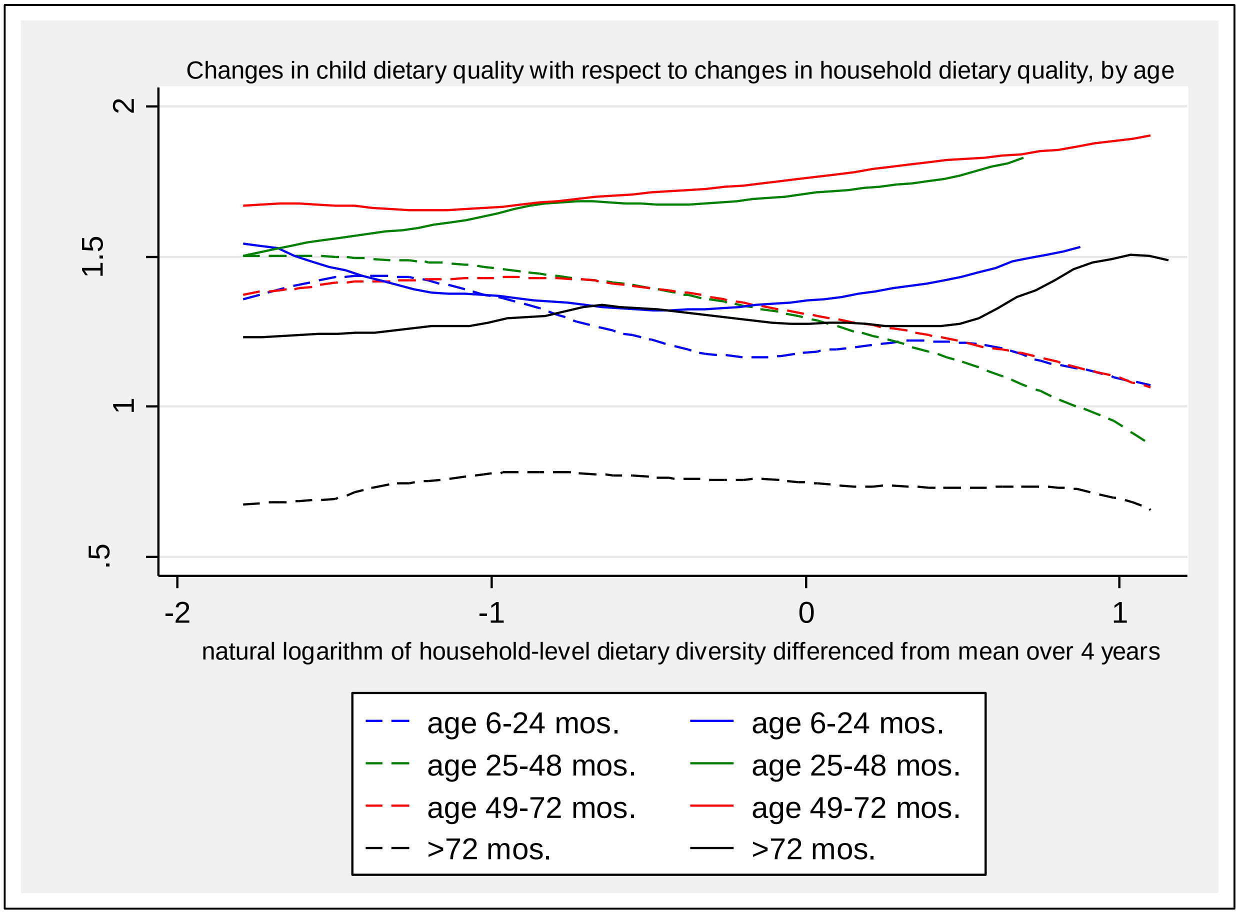
Child Characteristics	*N*	*DDS*	*ASF*	*Breastfeeding*
Units of measurement	Children	Count of foods (range 0-7)	Count of foods (range 0-3)	% of total
Girl children, < 60 months				
Mean	182	4.25	0.69	50%
SD		1.11	0.67	-
Girl children >= 60 months				

Mean	265	4.59	0.66	1.5%
SD		0.96	0.65	-
t-test p-value		0.305	0.39	-
Boy children, <60 months				
Mean	188	4.41	0.72	59%
SD		1.11	0.71	-
Boy children, >=60 months		4.28	0.65	
Mean	316	0.93	0.69	0%
SD				-
t-test p-value		0.31	0.39	-
All children				
Mean	951	4.37	0.69	21.5%
SD		1.05	0.68	-
t-test p-value		0.69	0.79	-

Notes: T-tests were performed to test the differences in means within sexes between age groups, and then for the sample as a whole at baseline between sexes. Two-sample t-test with equal variances; * p<.10, ** p<.05, *** p<.01.

Figure 2 below displays the nonparametric relationship between household and child dietary quality. The x-axis is the log of the difference between household dietary diversity in period *t* and the average across all periods *t=1* through *t=6*. The y-axis is the natural logarithm of child dietary diversity. The estimates for the chart are stratified by age group and length of exposure to the intervention. The solid lines indicate children who lived in communities where the intervention had been ongoing for two or three years. The dotted lines indicate children who lived in communities where the intervention had been ongoing for either zero years or one year. Children who lived in communities which had been exposed to the intervention longer experienced greater responsiveness to household diets during "harvest" seasons, i.e., during times of prosperity for the household. Conversely, children who hadn't been exposed to the intervention for as long did not share the gains during "harvest" seasons as much. Child diets for children in the youngest age group start off as relatively similar in their relationship to household diets, and then start to separate during the later survey rounds. Lastly, children in the oldest age group have diets that are the least responsive to household dietary changes; especially for the children who had been exposed to the intervention for less time. This chart provides a helpful visualization of the relationships between child and household dietary quality, but we also need to estimate the actual elasticities. These relationships are explored further with parametric estimates in Tables 4 through 7 below.

Figure 2: Child dietary quality with respect to household dietary quality



Solid lines: Had been exposed to the intervention for 2 or 3 years. Dotted lines: Had been exposed to the intervention for 0 or 1 year. The x-axis is the natural logarithm of child dietary diversity score.

Table 3 below displays the exploratory regression results. The two outcomes of interest are the natural logarithms of DDS and ASF consumption for children, defined as described above. Columns 1 and 4 are exploratory regressions in which the intervention enters as the number of years which the child has been exposed to the intervention. Columns 2 and 5 estimate the effects of the intervention using a difference-in-differences estimator. The estimated coefficient on the “Intervention*Phase” variable is the *average treatment effect on the treated* (ATET). Columns 3 and 6 incorporate individual fixed-effects into the estimates. The income and livestock herd size elasticity of dietary diversity – log(DDS) – and the elasticity of dietary diversity from animal sourced foods – log(ASF) – is not significantly different from zero across any of the three specifications. Child DDS and ASF is significantly associated with household DDS and ASF consumption, but not perfectly correlated. The elasticity of child ASF consumption with respect to household ASF consumption is smaller in magnitude at 0.77 in the fixed-effects model (Column 4) than the elasticity of child dietary diversity with respect to household dietary diversity at 0.86 (Column 2). Region does not have statistically significant associations with the indicators of child dietary quality. Women's education levels have a negative estimated association with child ASF consumption. Family land holdings and child sex are not significantly related to child dietary quality. Child age is significantly related to child dietary quality, but not after controlling for individual fixed-effects across survey rounds (Columns 3 and 6). The intervention alone is not significantly related to child dietary quality, nor is the difference-in-differences estimate of the coefficient on Intervention*Phase. There appears to be some effect modification between child age and sex.

Table 3: Exploratory Regressions

		(1)	(2)	(3)	(4)
Outcome	Units/type	Log(DDS)	Log(DDS)	Log(ASF)	Log(ASF)
Model		Exploratory	With D-in-D &FE	Exploratory	With D-in-D &FE
Time trend	Trend	-0.015***		-0.002	
		(0.004)		(0.776)	
Log(income)	Continuous	0.003	-0.007	0.007	-0.019
		(0.887)	(0.763)	(0.558)	(0.304)
Log(animals)	Continuous	0.004	-0.011	0.002	0.005
		(0.473)	(0.284)	(0.785)	(0.698)
Log(HH DDS)	Continuous	0.872***	0.860***		
		(0.000)	(0.000)		
Log(HH ASF)	Continuous			0.764***	0.777***
				(0.000)	(0.000)
Terai region	Binary	0.020		-0.001	
		(0.178)		(0.930)	
Women's Edu	Categorical	0.004		-0.011*	
		(0.382)		(0.073)	
Land (m^2)	Continuous	-0.000		-0.000	
		(0.402)		(0.256)	
Boy children	Binary	-0.009		0.004	
		(0.487)		(0.737)	
Child age	Months	0.001***	-0.000	-0.000	0.002

		(0.002)	(0.757)	(0.553)	(0.135)
Intervention	Years	-0.011	-0.011	0.017	-0.020
		(0.445)	(0.710)	(0.274)	(0.688)
Intervention*Phase	Interaction		0.008		-0.006
			(0.775)		(0.905)
Sex*Age	Interaction		-0.002*		-0.002**
			(0.054)		(0.032)
Constant	Constant	0.120	0.316	-0.001	0.243
		(0.591)	(0.222)	(0.993)	(0.235)
N		2247	2425	1381	1465

Notes: Group 1, having received the intervention starting one year earlier than Group 2, had longer durations for the "Intervention" variable. *p*-values in parentheses (* p<.10, ** p<.05, *** p<.01); Standard errors are clustered by family.

Tables 4 through 7 below present estimates of the elasticities of child dietary diversity and child animal source foods consumption with respect to household dietary diversity and animal source foods consumption. The resulting estimated coefficients are tested to ascertain if there are differences in dietary response across cohorts of interest. Table 4 presents estimates across sex cohorts. Child age is negatively related to dietary diversity, but it is not significantly related to the consumption of ASF. The time trend is statistically significant for DDS regressions but not ASF regressions. There are positive and statistically significant elasticities of child dietary quality with respect to household dietary quality across most groups, except for when households are in times of prosperity, when the relationship is not statistically significant. We cannot reject the null hypothesis in Equation (4) above that the coefficients are equal across sex cohorts. There has been evidence of sex bias in the intrahousehold allocation of foods in Nepal and elsewhere (Behrman and Deolalikar 1990; Alderman and Gertler 1997), but we do not see that here.

Table 4: Elasticities by sex

Variable Outcome	Units	(1) All DDS	(2) Prosp. DDS	(3) Stress. DDS	(4) All ASF	(5) Prosp. ASF	(6) Stress. ASF
Wald Test	F	F(1,2814)	F(1,913)	F(1,669)	F(1,1250)	F(1,557)	F(1,171)
Prob>F	p-value	0.197	0.584	0.299	0.861	0.593	0.137
Coefficients Differ?	-	No	No	No	No	No	No
Boys*Log(HH Diet)	Int.	0.552***	-0.313	0.410**	0.650***	0.647***	0.510***
		(0.000)	(0.251)	(0.029)	(0.000)	(0.000)	(0.000)

Girls*Log(HH Diet)	Int.	0.596***	-0.109	0.701***	0.642***	0.680***	0.871***
		(0.000)	(0.664)	(0.001)	(0.000)	(0.000)	(0.000)
Child age	Cont.	-0.020***	-0.008***	-0.017***	0.001	0.001	0.003
		(0.000)	(0.005)	(0.000)	(0.204)	(0.734)	(0.534)
Time trend	1 to 6	0.214***	0.191***	0.160***	-0.004	0.015	-0.040
		(0.000)	(0.000)	(0.000)	(0.706)	(0.287)	(0.232)
Constant	Constant	1.020***	1.658***	1.067***	-0.022	-0.041	0.002
		(0.000)	(0.000)	(0.000)	(0.521)	(0.412)	(0.992)
N		3769	1737	1402	2069	1269	571

For DDS regressions, Log(HH Diet) is measured as household DDS. For ASF regressions, Log(HH Diet) is measured as household animal source foods consumption. Wald tests were estimated across boy and girl children on the coefficients of the logged household DDS variables as indicated. Child fixed-effects are included for all models. *p*-values in parentheses; * p<.10, ** p<.05, *** p<.01; standard errors are clustered by family.

Child age is not examined as often as sex as a potential risk for inequitable intrahousehold distributions. A potential explanation for different dietary patterns across age groups is that younger children are more likely to be breastfed, providing some nutritional protection. Below, Table 5 presents estimates of the same models, but with age cohorts instead of sex cohorts. Here, there are strong and statistically significant relationships between household and child dietary diversity and ASF consumption. Elasticity estimates range from -0.45 to 0.96 across all age groupings and model specifications. The time trend is statistically significant across all columns. Depending on whether the household is experiencing a time of relative stress or a time of relative prosperity, elasticities increase with age or decrease with age. Based on the Wald Tests, we can reject the null hypotheses in Equation (4) above that the coefficients are equal across age groups. The child dietary response with respect to household dietary quality is not the same across age cohorts.

Table 5: Elasticities split by age group, not including breastfed children

		(1)	(2)	(3)	(4)	(5)	(6)
Variable	Units	All	Prosp.	Stress.	All	Prosp.	Stress.
Outcome		DDS	DDS	DDS	ASF	ASF	ASF
Wald Test	F-stat	F(3,1623)	F(3,490)	F(3,353)	F(3,708)	F(3,290)	F(3,86)
Prob>F	P-value	0.014***	0.556	0.037**	0.001***	0.000***	0.001***
Coefficients Differ?	-	Yes	No	Yes	Yes	Yes	Yes
6-24 M.*Log(HH Diet)	Int.	0.540***	0.763***	0.686***	-0.195	-0.138	-
		(0.000)	(0.000)	(0.000)	(0.358)	(0.515)	-
25-48 M.*Log(HH Diet)	Int.	0.526***	0.793***	0.558***	0.645***	0.687***	0.884**

		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.034)
49-71 M.*Log(HH Diet)	Int.	0.559***	0.816***	0.497***	0.790***	0.940***	0.964***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
>72 M.*Log(HH Diet)	Int.	0.602***	0.826***	0.456***	0.813***	0.838***	0.697***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time trend	1 to 6	0.093***	0.005	0.081***	-0.034***	-0.035**	-0.092**
		(0.000)	(0.719)	(0.000)	(0.004)	(0.047)	(0.017)
Constant	Cons.	1.546***	0.373**	1.240***	-0.035	-0.138*	-0.195
		(0.000)	(0.024)	(0.000)	(0.493)	(0.082)	(0.395)
N		2416	1129	903	1382	830	358

Children who are breastfed, regardless of age, are excluded from these estimates. There are four age groupings used for these regressions: 6-24 Months (Complementary Feeding), 25-48 Months (Older toddler and preschool), 49-72 Months (Preschool and school age), and >72 Months (School age). For DDS regressions, Log(HH Diet) is measured as household DDS. For ASF regressions, Log(HH Diet is measured as household animal source foods consumption. Wald tests were estimated across age groupings on the coefficients of the logged household DDS variables as indicated. Child fixed-effects are included for all models. *p*-values in parentheses; * p<.10, ** p<.05, *** p<.01; standard errors are clustered by family.

Previous work using these data up to the 24-month survey point found evidence of differential responses to the intervention across regions. The two main regions where study participants lived were the Hills and the Terai. The Hills are poorer on average and more conducive to livestock production, while the Terai, is richer on average and more conducive to crop production. In these models, child age and the time trend are significantly related to child dietary quality only when it is measures as dietary diversity. In the Terai, elasticity estimates range from 0.33 to 0.69. In the Hills, elasticity estimates range from 0.632 to 1.11. Based on the Wald Tests, we can reject the null hypotheses in Equation (4) above that the coefficients are equal across regions, for Columns 1, 3, and 6. We cannot reject that null hypothesis for columns 2, 4, and 5. In times of stress (Columns 3 and 6), the elasticity of child DDS with respect to household DDS is 0.33 in the Terai region, but 0.96 in the Hills. A similar pattern holds when measuring dietary quality with ASF consumption, for which the elasticity is 0.39 in the Terai and 1.11 in the Hills. Thus, for select model specifications, the responsiveness of child diets to changes in household diets differs across regional groups.

Table 6: Elasticities split by region

		(1)	(2)	(3)	(4)	(5)	(6)
Variable	Units	All	Prosp.	Stress.	All	Prosp.	Stress.
Outcome		DDS	DDS	DDS	ASF	ASF	ASF
Wald Test	F-stat	F(1,2814)	F(1,913)	F(1,669)	F(1,1250)	F(1,557)	F(1,171)

Prob>F	P-value	0.005***	0.114	0.036**	0.189	0.099*	0.004***
Coefficients Differ?	-	Yes	No	Yes	No	No	Yes
Terai*Log(HH Diet)	Int.	0.534***	0.074	0.327*	0.624***	0.628***	0.392***
		(0.000)	(0.772)	(0.058)	(0.000)	(0.000)	(0.003)
Hills*Log(HH Diet)	Int.	0.632***	-0.519*	0.959***	0.687***	0.737***	1.109***
		(0.000)	(0.056)	(0.000)	(0.000)	(0.000)	(0.000)
Age (Months)	Cont.	-0.020***	-0.008***	-0.018***	0.001	0.001	-0.001
		(0.000)	(0.005)	(0.000)	(0.209)	(0.652)	(0.892)
Time trend	t	0.215***	0.188***	0.166***	-0.004	0.014	-0.022
		(0.000)	(0.000)	(0.000)	(0.714)	(0.313)	(0.516)
Constant	Cons.	1.018***	1.547***	1.081***	-0.022	-0.048	0.150
		(0.000)	(0.000)	(0.000)	(0.533)	(0.331)	(0.385)
N		3769	1737	1402	2069	1269	571

For DDS regressions, Log(HH Diet) is measured as household DDS. For ASF regressions, Log(HH Diet is measured as household animal source foods consumption. Wald tests were estimated across regional groupings on the coefficients of the logged household DDS variables as indicated. Child fixed-effects are included for all models. *p*-values in parentheses; * p<.10, ** p<.05, *** p<.01; standard errors are clustered by family.

One of our main hypotheses was that longer exposure to the intervention will make the distribution of foods within the household more equitable. This hypothesis is tested below with the regressions presented in Table 7a. Here, we estimate the responsiveness of child dietary quality to household dietary quality, in cohorts which indicate the length of time a child has been exposed to the intervention. The first row is the cohort which had not yet been exposed to the intervention. For this cohort, elasticities of child dietary quality with respect to household dietary quality range from -0.66 to 0.51. The second row is the cohort which had been exposed to the intervention for one year, and the estimated elasticities range from -0.34 to 0.89. The third row is the cohort which had been exposed to the intervention for at least two years, and elasticities range from 0.58 to 0.80. For the group which had been exposed to the intervention for at least 3 years, elasticities range from 0.735 to 1.12 across all specifications. Based on the Wald Tests, we can reject the null hypotheses in Equation (4) above that the coefficients are equal across age groups, except for Column 3, where we cannot reject the null hypothesis that the coefficients are equal. Thus, the child dietary response with respect to household dietary quality is not the same across treatment level cohorts. The responsiveness of child dietary quality increases as the length of time exposed to the intervention increases. For times of prosperity and hardship combined, Columns 1 and 4, elasticities range from quite inelastic at 0.32 and 0.47 with no exposure to the intervention to 0.89 and 0.93 with three years of exposure to the intervention.

Table 7: Elasticities split by length of treatment

Variable Outcome	Units	(1) All DDS	(2) Prosp. DDS	(3) Stress. DDS	(4) All ASF	(5) Prosp. ASF	(6) Stress. ASF
Wald Test	F-stat	F(3,2813)	F(3,912)	F(3,668)	F(3,1249)	F(3,556)	F(3,170)
Prob>F	P-value	0.001***	0.001***	0.068*	0.001***	0.001***	0.023**
Coefficients Differ?	-	Yes	Yes	No	Yes	Yes	Yes
0 years*Log(HH Diet)	Int.	0.317***	-0.661***	0.452***	0.472***	0.514***	0.054
		(0.000)	(0.001)	(0.002)	(0.000)	(0.000)	(0.834)
1 years*Log(HH Diet)	Int.	0.534***	-0.343*	0.565***	0.595***	0.596***	0.892***
		(0.000)	(0.060)	(0.000)	(0.000)	(0.000)	(0.000)
2 years*Log(HH Diet)	Int.	0.758***	-0.009	0.675***	0.731***	0.800***	0.581***
		(0.000)	(0.959)	(0.000)	(0.000)	(0.000)	(0.000)
3 years*Log(HH Diet)	Int.	0.897***	0.185	0.735***	0.903***	0.883***	1.119***
		(0.000)	(0.343)	(0.000)	(0.000)	(0.000)	(0.001)
Age (Months)	Cont.	-0.009***	-0.011***	-0.004	0.000	0.001	-0.002*
		(0.000)	(0.001)	(0.207)	(0.925)	(0.160)	(0.063)
Constant	Cons.	1.069***	2.617***	0.741***	0.046*	-0.009	0.184**
		(0.000)	(0.000)	(0.003)	(0.060)	(0.815)	(0.017)
N		3769	1737	1402	2069	1269	571

For DDS regressions, Log(HH Diet) is measured as household DDS. For ASF regressions, Log(HH Diet is measured as household animal source foods consumption. Wald tests were estimated across treatment length groupings on the coefficients of the logged household DDS variables as indicated. Child fixed-effects are included for all models. *p*-values in parentheses; * p<.10, ** p<.05, *** p<.01; standard errors are clustered by family. A time trend was not included in these estimates, because it would have been perfectly collinear with the length of time a community was exposed to the intervention.

4.5. Strengths, limitations, and possible extensions

The strengths of this study include the random assignment across villages which allows for valid comparison of the program's effects between Group 1 and Group 2, the semi-annual survey implementation which allows for the analysis of seasonal patterns in dietary quality, the inclusion of older children up to age 8, which is a rare occurrence in dietary quality studies, and the combination of the individual-level and household-level 24 hour diet diversity recall data. The main limitation of this study was that women's empowerment and level of participation in the *Self-Help Groups* was not actually measured. Instead, we utilized a proxy – community-level participation in the Heifer *Self-Help Groups* – to indicate women's relative empowerment. Field trials and community development projects should regularly measure key variables through which interventions and programs are expected to cause improvement. Extensions to the current empirical analysis should include the incorporation of family fixed-effects, in an across-sibling analysis. Alternative measures of dietary diversity should also be incorporated. Traditionally, the nutrition literature utilizes eight foods and food groups to calculate child dietary diversity (WFP 2010), but in the applied economics literature, other foods are often included, such as processed foods, spices, oils, and sweets. In the former case, dietary diversity is intended to indicate dietary quality only, whereas in the latter case, dietary diversity could encompass other aspects of well-being. More Wald Tests should be performed to test differences across specific coefficients in each model specification. Lastly, alternative time-variant controls such as livestock holdings, income, and prices should be incorporated into elasticity estimates.

5. CONCLUSION

In rural Nepal, child-level dietary quality is highly related to household-level dietary quality. However, these relationships differ depending on age of the child, the region, and the exposure to a community-level development intervention. Over time, community-level development interventions can affect the responsiveness of child dietary quality with respect to household dietary quality. Previous work had demonstrated that the Heifer intervention improved child dietary quality in the Hills, but not the Terai. The analysis in this article demonstrates that a major reason for those findings was that the elasticity of child-level ASF with respect to the household-level ASF was much higher in the Hills (1.12) than the Terai (0.74) after three years of exposure to the intervention. The elasticity of child dietary diversity with respect to household dietary diversity is different across age cohorts of children, across regions of Nepal, and across intervention cohorts, but not across sex cohorts. Children with larger elasticities will enjoy greater shares of the nutritional reward during prosperous times ("harvest" seasons) for households; but also they will disproportionately bear the burden during difficult times ("hungry" seasons) (Behrman and Deolalikar 1990). Thus, changes in household dietary quality may mask underlying changes in dietary quality for individuals within the household. These results indicate that intra-household dynamics for the distribution of foods is not equal across key demographic groupings, and that this matters for the effectiveness of community-level development projects. Notably, the magnitudes of estimated elasticities increase as the length of exposure to the intervention increases, independent of other time-variant or individual time-invariant factors. Furthermore, the responsiveness of child dietary quality to household dietary quality increases with child age, except during periods of stress for households, when younger children experience relatively larger dietary responses.

6. REFERENCES

Alderman H, Gertler P. Family resources and gender differences in human capital investments: The demand for children's medical care in Pakistan. Intrahousehold Resource Allocation in Developing Countries. 1997:231-48.

Allendorf, Keera. "Do Women's Land Rights Promote Empowerment and Child Health in Nepal?" *World Development* 35.11 (2007): 1975-88.

Arimond, Mary, and Marie T. Ruel. "Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys." *The Journal of nutrition* 134, no. 10 (2004): 2579-2585.

Arimond, Mary, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa C. Daniels, Megan Deitchler, Nadia Fanou-Fogny et al. "Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings." *The Journal of Nutrition* 140, no. 11 (2010): 2059S-2069S.

Arimond, Mary, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa C. Daniels, Megan Deitchler, Nadia Fanou-Fogny et al. "Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings." *The Journal of Nutrition* 140, no. 11 (2010): 2059S-2069S.

Behrman JR, Deolalikar AB. The intrahousehold demand for nutrients in rural south India: Individual estimates, fixed effects, and permanent income. Journal of human resources. 1990 Oct 1:665-96.

Belachew T, Hadley C, Lindstrom D, Gebremariam A, Michael KW, Getachew Y, Lachat C, Kolsteren P. Gender differences in food insecurity and morbidity among adolescents in southwest Ethiopia. Pediatrics. 2011 Feb 1;127(2):e398-405.

Carletto, G., Ruel, M., Winters, P., & Zezza, A. (2015). Farm-Level Pathways to Improved Nutritional Status: Introduction to the Special Issue. *The Journal of Development Studies*.

Chen, Lincoln C., Emdadul Huq, and Stan D'Souza. "Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh." *Population and Development Review* 7.1 (1981): 55-70. Web.

Darrouzet-Nardi, A.F., Miller, L.C., Joshi, N., Mahato, S., Lohani, M. and Rogers, B.L., 2016. Child dietary quality in rural Nepal: Effectiveness of a community-level development intervention. *Food Policy*, *61*, pp.185-197.

Food and Agriculture Organization of the United Nations. GLIPHA. Livestock Population (Dataset). <http://data.fao.org/ref/4813cbb2-21f0-4f6c-aebe-8855b340dadd.html?version=1.0> (Latest update: 21 Nov 2013, Accessed 21 Nov 2013)

Gittelsohn, Joel. "Opening the Box: Intrahousehold Food Allocation in Rural Nepal." *Social Science & Medicine* 33.10 (1991): 1141-54. *MEDLINE.* Web.

Graham, Margaret A. "Food Allocation in Rural Peruvian Households: Concepts and behavior regarding Children." *Social Science & Medicine* 44.11 (1997): 1697-709.

Heifer International Nepal. Available at: http://www.heifernepal.org/. Accessed 31 May 2014.

Hill, Kenneth, and Dawn M. Upchurch. "Gender differences in child health: evidence from the demographic and health surveys." *Population and Development Review* (1995): 127-151.

Jin, M. and Iannotti, L.L., 2014. Livestock production, animal source food intake, and young child growth: The role of gender for ensuring nutrition impacts. *Social Science & Medicine*, *105*, pp.16-21.

Kabeer, Naila. "Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment." *Development and change* 30.3 (1999): 435-64.

Kabeer, Naila. "Is Microfinance a 'Magic Bullet' for Women's Empowerment? Analysis of Findings from South Asia." *Economic and Political weekly* (2005): 4709-18.

Linnemayr, Sebastian, Harold Alderman, and Abdoulaye Ka. "Determinants of Malnutrition in Senegal: Individual, Household, Community Variables, and their Interaction." *Economics & Human Biology* 6.2 (2008): 252-63.

Malapit, Hazel Jean L., and Agnes R. Quisumbing. "What dimensions of women's empowerment in agriculture matter for nutrition in Ghana?." *Food Policy* 52 (2015a): 54-63.

Malapit, Hazel Jean L., Suneetha Kadiyala, Agnes R. Quisumbing, Kenda Cunningham, and Parul Tyagi. "Women's empowerment mitigates the negative effects of low production diversity on maternal and child nutrition in Nepal." *The Journal of Development Studies* 51, no. 8 (2015b): 1097-1123.

Messer, Ellen. "Intra-Household Allocation of Food and Health Care: Current Findings and Understandings—introduction." *Social Science & Medicine* 44.11 (1997):1675-84.

Miller LC, Joshi N, Lohani M, Rogers B, Loraditch M, Houser R, Singh P, Mahato S. Community development and livestock promotion in rural Nepal: Effects on child growth and health. Food and nutrition bulletin. 2014 Sep 16;35(3):312-26.

Ministry of Health and Population (MOHP) [Nepal], New ERA, and ICF International Inc. 2012. *Nepal Demographic and Health Survey 2011.* Kathmandu, Nepal: Ministry of Health and Population, New ERA, and ICF International, Calverton, Maryland.

Prentice, Ross L., Yasmin Mossavar-Rahmani, Ying Huang, Linda Van Horn, Shirley AA Beresford, Bette Caan, Lesley Tinker et al. "Evaluation and comparison of food records, recalls, and frequencies for energy and protein assessment by using recovery biomarkers." *American journal of epidemiology* (2011): kwr140.

Trapp EM, Williams J, Menken J, Fisher S. Disappearing sex-bias in child health in Bangladesh. Population Aging Center Working Paper. 2004 Mar 18;3.

Rawlins R, Pimkina S, Barrett CB, Pedersen S, Wydick B. Got milk? The impact of Heifer International's livestock donation programs in Rwanda on nutritional outcomes. Food Policy. 2014 Feb 28;44:202-13.

Rogers BL. The internal dynamics of households: A critical factor in development policy. Intra-Household Resource Allocation: Issues and Methods for Development Policy and Planning. 1990:1-9.

Rogers, B.L., 1996. The implications of female household headship for food consumption and nutritional status in the Dominican Republic. *World Development*, *24*(1), pp.113-128.

Ruel, Marie T., Harold Alderman, and Maternal and Child Nutrition Study Group. "Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition?" *The Lancet* 382.9891 (2013): 536-551.

StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.

Villa KM, Barrett CB, Just DR. Whose fast and whose feast? Intrahousehold asymmetries in dietary diversity response among East African pastoralists. American Journal of Agricultural Economics. 2011 Jul 1;93(4):1062-81.

Wald A. Sequential tests of statistical hypotheses. The Annals of Mathematical Statistics. 1945 Jun 1;16(2):117-86.

World Bank Group, ed. *World development indicators 2012*. World Bank Publications, 2012.

World Food Programme. *Nepal: A Report on the Food Security Impact of the 2015 Earthquake.* WFP, May 2015. Web.

World Health Organization (2010) *Indicators for assessing infant and young child feeding practices.* Geneva: World Health Organization.