Considering Context: Variation in Food Availability and Diet Quality Among Children in Nepal's Three Agroecological Zones

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Abstract

Background: Poor quality diets put Nepali children at risk for undernutrition. Designing and implementing interventions to effectively improve child diet quality requires an understanding of how contextual factors influence household access to non-staple nutritious foods. The Policy and Science for Health, Agriculture, and Nutrition (PoSHAN) data collection system monitors agricultural production, household food security, dietary intake, and nutritional status at 21-sites across Nepal. It offered a unique opportunity to examine child diet quality and household food access across varying agroecological settings and seasons. Additionally, the large integrated nutrition program Suaahara (meaning 'good nutrition' in Nepali) provided a chance to observe a nutrition-sensitive agriculture program's efforts to improve food access and diet quality in one of Nepal's most extreme settings.

Methods: Chapter four quantitatively examines seasonal differences in children's consumption frequency of non-staple nutritious food consumption frequency. It uses data from the PoSHAN study's sentinel surveillance sites. In these three sites, data were collected three times per year over the course of two years. Analyses were conducted separately by region, allowing for assessment of how seasonal variation differed geographically. Interactions between season and caste/ethnicity and wealth were also explored. Chapter five also uses PoSHAN sentinel site data. It first examines associations between household food production and purchasing and children's consumption of nutritious foods. It then analyzes associations between season, region, caste/ethnicity, and wealth and household food production and purchasing. Chapter six qualitatively examines implementation of the Suaahara program's agriculture component in far-Western Nepal. It identifies and describes contextual factors that influenced participants' abilities to engage in and benefit from the program.

Results: Children's consumption frequency of non-staple nutritious foods varied significantly by season. The magnitude and timing of seasonal differences differed by region, and in some cases by wealth and caste/ethnicity. Both household production of and household expenditure on nutritious foods were associated with their consumption frequency among children. Region, season, land ownership, and wealth influenced the likelihood of households producing and purchasing nutritious foods. Within the qualitative findings, water, land, and time emerged as key determinants of women's abilities to engage in and benefit from a nutrition-sensitive agriculture program. Access to these resources depended upon sociocultural and biophysical environmental factors, as well as historic land and labor policies. Program participants and staff used a variety of strategies to address resource access challenges. These included: use of micro-irrigation equipment, arranging land-sharing agreements, engaging families in program activities, and role-modeling more equitable gendered division of labor. However, the feasibility of these strategies was also limited by contextual constraints.

Conclusions: Access to nutritious foods, and subsequently child diet quality, vary substantially across Nepal's agroecological regions. Sources of variation lie in both the biophysical and sociocultural environment, and must be understood in the context of current and historic policies and institutions. Interventions that increase year-round household production and purchasing of nutritious foods hold substantial promise for improving child diet quality, but must be tailored at the regional and even community level. More broadly, enabling interventions to reach and benefit the most marginalized households, and addressing the root causes of poor diet quality, will require addressing complex structural barriers. Chief among these are improvements in irrigation infrastructure, enactment of land reform, and establishment of robust social protection mechanisms.

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"Nothing can dim this golden sunshine in our hearts." –Melissa Anne Prestosa

For Will & Vinny, my favorite creatures.

Table of Contents

Tables

Figures

List of terms and abbreviations

AIC	Akaike's Information Criterion
BIC	Bayesian Information Criterion
CFK	Complementary Feeding Knowledge
CI	Confidence Interval
FCHV	Female Community Health Volunteer
FFQ	Food Frequency Questionnaire
FGD	Focus Group Discussion
GEE	Generalized Estimation Equations
HDI	Human Development Index
HDMP	Household Decision-Making Participation
HFP	Homestead Food Production
HKI	Helen Keller International
IDI	In-Depth Interview
IQR	Inter-Quartile Range
IRB	Institutional Review Board
IRR	Incident Rate Ratio
JHSPH	Johns Hopkins Bloomberg School of Public Health
NGO	Non-Governmental Organization
NPR	Nepali Rupee
OR	Odds Ratio
PCA	Principal Components Analysis
PoSHAN	Policy and Science of Health, Agriculture, and Nutrition
RQ	Research Question
SD	Standard Deviation
USAID	United States Agency for International Development
USD	United States Dollars
VDC	Village Development Committee
WASH	Water, Sanitation, and Hygiene

Chapter 1. Introduction

1.1 Background

Over the past decade, Nepal's efforts in the health sector have dramatically reduced infant and child mortality; however, the challenge of undernutrition persists. According to the 2011 Demographic and Health Survey, 41% of children under age five are stunted and 46% of children between six months and five years are anemic[1]—dire indicators because undernutrition impairs a child's cognitive and physical development.[2, 3] As suggested by the high prevalence of anemia, along with protein-energy malnutrition, micronutrient deficiencies pose a critical problem among children in Nepal.[4] A 2014 study by Schulze et al. found that among a sample of 1000 children between six and eight years old, nearly 92% experienced at least one micronutrient deficiency, and nearly 65% experienced multiple deficiencies.[5]

The quality of a child's diet is a crucial determinant of micronutrient status as well as overall nutrition status.[6] In settings like Nepal, where the diet is characterized by high intake of rice and other staple grains, consumption of nutritious non-staple foods (fruits, vegetables, legumes, and animal source foods) largely determine diet quality. [7, 8] The necessity of increasing access to and consumption of non-staple foods is now widely recognized, particularly in settings where agriculture is the primary source of livelihood.[6, 9, 10] Therefore, many nutrition programs now aim to promote agricultural strategies that can increase household access to non-staple nutrient-rich foods.[9-13] Such programs take a wide variety of forms, but many promote both production and purchasing of fruits and vegetables and animal source foods, and aim to improve knowledge, particularly among mothers, regarding the importance of including such foods in the diets of young children.[14-17]

Increasingly, nutrition program planners and researchers are asking how to effectively scale-up interventions across diverse settings.[10, 18] They emphasize the need for a better understanding of the setting-specific factors that influence current food production and consumption practices as well as intervention feasibility.[18, 19] In a recently published framework and research agenda for strengthening implementation and utilization of nutrition interventions, Menon et al. discuss the multiple levels at which contextual influences occur and emphasize their effects on demand, utilization, adherence, and sustainability.[19] They mention education, beliefs, resource constraints, and gender dynamics. However, they neglect contextual factors that occur above the individual or household level. This is problematic because research focused at the individual and household level will point towards individual- and household-level solutions. To develop larger-scale solutions we need to ask questions about factors operating at higher levels.

A full understanding of how context influences child diet quality, and strategies to improve diet quality, requires expanding our scope beyond the individual and household level. As Fiorella et. al. write, "the political, economic, and environmental context in which agricultural interventions operate undoubtedly shape patterns of household livelihoods and food consumption, and interventions' success in enhancing, diversifying, or altering these (p.45)." [17] In their review of the existing literature on agricultural interventions, they note that few studies take political economy or socio-environmental context into account. They call on agriculture-nutrition researchers to pay greater attention to complex contextual factors, including resource access, land tenure, weather, and other aspects of changing environments.[17]

The objective of this dissertation is therefore to examine how contextual factors that operate above the individual or household level influence child diet quality in Nepal, and their

implications for strategies that aim to improve child diet quality. Nepal's dramatic geographic diversity provides a unique opportunity to examine the influence of context. The country's terrain falls into three distinct categories characterized by climate and topography: the mountains, hills, and low-lying plains. Referred to as agroecological zones, they run East to West across the country. The low-lying plains region, usually referred to as the Terai, is contiguous with the plains of India. The Terai is the most fertile and populated of the three regions, while the mountains have the lowest population and the least amount of cultivable land.

This dissertation begins with a broad look at differences in child diet quality by season and region (manuscript one). Next, I examine the mechanisms through which these differences occur (manuscript two). Finally, I qualitatively explore the implementation of a nutrition-sensitive agriculture intervention (manuscript three). This allows for a more nuanced understanding of the contextual factors examined in the previous analyses, and inductive identification of additional important factors.

1.2 Study aims

Aim 1: Quantitatively examine seasonal differences in children's consumption frequency of non-staple nutritious foods across Nepal's three agroecological regions, and assess whether seasonal consumption patterns vary by wealth and caste/ethnicity;

Aim 2: Quantitatively examine the relationships between household production and purchasing of nutritious foods and children's dietary intake among Nepali agricultural households, and identify contextual factors that influence a household's likelihood to produce or purchase nutritious foods;

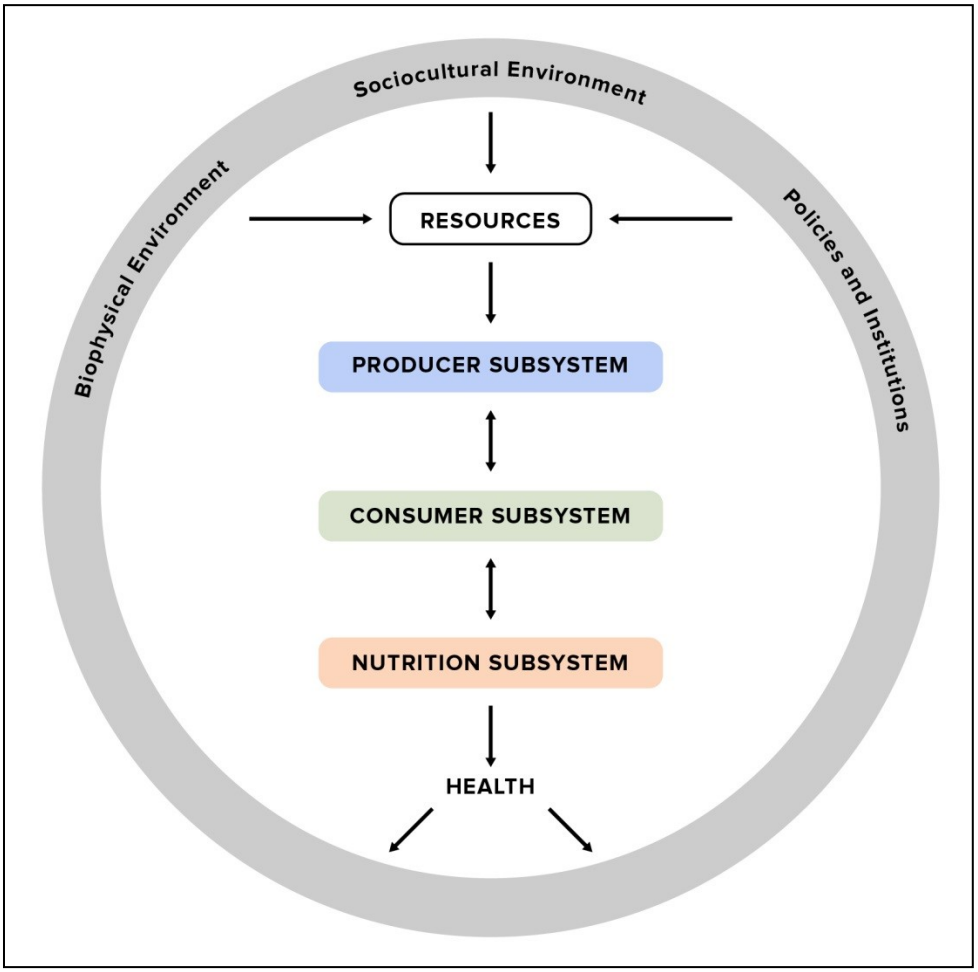
Aim 3: Qualitatively examine the contextual factors that affect participants' abilities to engage in and benefit from a nutrition-sensitive agriculture program in Nepal's far-western mountains.

1.3 Theoretical framework

A systems approach to understanding food and nutrition informs this research. Food and nutrition system models "describe the complex set of activities involved in providing food for sustenance and nutrients for maintaining health (p.853)," as well as the forces that influence those activities, including agricultural, economic, and ecological factors.[20] As Sobal et. al. explain, food system models are useful conceptual tools for researchers because they, "reveal connections between parts of the system and suggest analyses for problems related to the system (p.853)."[20] Moreover, they acknowledge the complex and often contradictory relationships and the feedback loops between individual, collective, and ecological well-being.

Drawing on Sobal et al.'s [20] work, Burchi, Fanzo, and Frison [9] succinctly articulate the key components and relationships of an integrated food and nutrition system. A diagram illustrating the system appears in Figure 1. Specifically, they highlight the interaction between what they define as producer, consumer, and nutrition subsystems. The producer subsystem includes the production, distribution, and selling of foods. The consumer subsystem includes accessing food by growing or purchasing it, preparing it, and consuming it (including feeding it to children). Finally, the nutrition subsystem includes digestion of food, absorption of nutrients, and transport and utilization of nutrients.

Figure 1. Burchi, Fanzo, and Frison's (9) depiction of an integrated food and nutrition system (adapted from Sobal et al.(20))



Burchi et al.[9] emphasize the interactions and non-linear feedbacks between the producer, consumer, and nutrition subsystems. They also emphasize the importance of three types of contextual factors that influence those subsystems: factors in the biophysical environment, factors in the socio-cultural environment, and factors related to policies and institutions. They assert that strategies for improving food and nutrition security must attend to the factors and relationships in this system.

This conceptual framework can be situated within the agency vs. structure debate engaged in widely within the field of sociology. Arising from the work of Bourdieu,[21] Weber,[22] and Giddens,[23] this debate centers on the role of individual free will and choice (agency) vs.

social norms and access to resources (structure) in determining human behavior and actions. More recently, sociologists such as Cockerham, Frohlich, and Delormier have drawn on this debate to articulate theories of health-related behavior, including food choice.[24-26] They emphasize the importance of examining how the structural factors within a given context impact the agency of individuals in that context, and subsequently influence their actions.

Cockerham asserts that such a perspective serves as a crucial counterpoint to the overly narrow focus on individual-level determinants of behavior and health outcomes often found within public health and epidemiology. He explains that, "while agency is important… structural conditions can act back on individuals and configure their lifestyle patterns in particular ways. Agency allows them to reject or modify these patterns, but structure limits the options that are available."[24] Viewed through this lens, the food system framework illustrated above shows how individuals exert agency over their own nutrition and health through their behavior as producers and consumers. However, they are also situated within a context of broader structural forces (the biophysical environment, the sociocultural environment, and policies and institutions) which constrain agency, primarily via access to resources.

1.4 Organization of the dissertation

The first chapter of this dissertation introduces the study and describes the theoretical framework that guided the research question development, data analysis, and interpretation. The second chapter describes the literature addressing key topics examined in the study and provides information on the districts in Nepal where research activities were carried out. Chapter three provides information on the data sources and data collection methods used for both the quantitative and qualitative portions of this dissertation. Chapters four through six include three manuscripts prepared for submission to peer-reviewed journals. Chapter four

describes a longitudinal analysis examining the seasonal differences in children's consumption of three key non-staple nutritious foods. Chapter five describes a series of three analyses. The first analysis examines the relationship between household production and expenditure on three non-staple nutritious foods and children's consumption of those foods. The second and third analyses examine predictors of a household's likelihood of producing or purchasing a given food. Finally, chapter six presents a qualitative analysis of interviews and focus-group discussions conducted with the participants and staff of a nutrition-sensitive agriculture intervention in the district of Bajura. The final chapter of this dissertation, chapter seven, synthesizes the dissertation's findings and situates them within a conceptual model based upon Burchi et. al.'s food and nutrition system framework. It then discusses the programmatic and policy implications of these findings.

Chapter 2. Literature Review and Research Setting

2.1 Importance of Non-Staple Nutritious Foods

Fruits and vegetables, pulses, dairy, eggs, fish, and flesh foods are often referred to as "non-staple" foods to distinguish them from the grains, roots and tubers (referred to contrastingly as "staple foods") that comprise the bulk of diets in low-income countries.[27] Because staple grains are generally poor sources of bioavailable protein and micronutrients, non-staple nutritious foods are crucial contributors to the nutritional adequacy of a diet.[6, 28] In a recent study of global reductions in stunting achieved over the past thirty years, Smith & Haddad found that increases in amount of total energy intake from non-staple foods explained a significant portion of stunting reduction achievements.[8] However, non-staple foods are also more expensive relative to staple grains, so when resources are limited or if the price of staple foods go up, households generally reduce their consumption of non-staple foods.[29]

According to Ruel, Harris, and Cunningham, a high-quality diet is defined as one that provides "the right nutrients in the right amounts for health and wellbeing."[6] Diet quality therefore depends largely on the extent to which non-staple nutritious foods are consumed. Variety is particularly important—i.e. the greater the number of food groups consumed, the greater the likelihood that nutrient intake is adequate.[6] For this reason, dietary diversity indices—calculated by summing the number of food groups consumed within a given period of time—are now frequently used as proxies for diet quality. Studies by Arimond and Moursi have demonstrated that dietary diversity index scores are correlated with the micronutrient density of women's and children's diets. [28, 30] While useful for characterizing diet quality as a whole, aggregate dietary diversity measures obscure the specific food groups consumed and those which are lacking. Given that households obtain different food types through different

processes, examining consumption of specific non-staple nutritious foods is more informative than overall dietary diversity if the goal of the analysis is to inform intervention strategies.

In Nepal, as in many other low-income settings, children consume a primarily cereal-based diet very low in micronutrients and with overall insufficient energy intake.[31] [32] Pulses, usually lentils, are a core component of the Nepali diet and are consumed twice a day in the vast majority of households. However, they are prepared as a soup (daal) which means their contribution to nutrient intake depends on the water to lentil ratio and is often minimal.[33] [34] Nutritionally important foods groups that are infrequently consumed include vitamin A-rich fruits and vegetables and animal source foods.[35-39] Recent data from the 2012 baseline survey for a large nutrition intervention indicated that within the 16 districts in Nepal where data were collected, only 46% of children between six months and two years received the minimum dietary diversity (consuming foods from at least four groups in a 24-hour period), and only 36% of children received the minimal acceptable diet (adequate frequency of consumption as well as diversity).[40]

2.2 Importance of Seasonality

Effectively addressing undernutrition requires renewed attention to the seasonal hunger faced by millions of the rural poor in low-income countries.[41] The 2015 Global Nutrition Report asserts that it is "time to take seasonality more seriously," and calls for improved data on seasonal trends in food production, diet and nutritional status.[42] It also emphasizes the need for greater priority to be given to interventions that help households manage seasonal variation.

Attention towards seasonality within nutrition programs and within the food security literature usually focuses on challenges posed by the "lean season," meaning the period between harvests when stored grain and other staple foods from a previous harvest are running

low. In nearly all subsistence agriculture settings, a pattern emerges of greater energy intake immediately after the harvest season, and then decreased intake in the months prior to the next harvest.[41] We know far less about the seasonality of non-staple food consumption. Unlike grains, tubers, and other staples, fruits and vegetables and animal source foods are perishable and cannot be stored. This means seasonal consumption patterns are likely to be far more erratic, and immediately responsive to factors that impede production. Additionally, they will vary substantially depending on food type.[33] Therefore, periods of greatest vulnerability to inadequate energy intake due to depleted staple grains during the lean season, and periods of greatest vulnerability to micronutrient deficiencies may not overlap. A better understanding of the seasonality of non-staple foods is crucial for informing strategies to address both types of nutritional vulnerability.

The Global Nutrition Report also describes seasonality as an important factor that mediates climate change and nutrition status, and as an indicator of vulnerability to climate risk.[42] Climate variability strongly influences agricultural production,[43] and a recent study indicates that temperature and rainfall deviations negatively impact agricultural diversity, reducing fruit and vegetable yields more than staple crop yields.[44] This suggests that climate change-related weather anomalies may threaten the quality of food available, prior to impacting quantity. Examining seasonal variation in dietary quality and food access may indicate what types of assistance will be needed to help families adapt to increasing climate variability.

Several studies have documented seasonal differences in diet or nutritional status in Nepal. Three examined differences in children's dietary intake in the hills region (summarized in the first paragraph below), and two examined differences in children's dietary intake in the Terai and mountains (second paragraph below). One study examined seasonal differences in women's

dietary intake in the Terai (third paragraph). Two others examined seasonal differences in child growth, one in the hills region, and one using nationally representative data (fourth paragraph below). Finally, one study examined seasonal differences in the micronutrient status of pregnant women, and another examined birth outcomes (fifth paragraph).

Panter-Brick [31] compared the energy intake of 23 children living in Nepal's central hills during the monsoon season and during the spring. This author observed significant seasonal differences in total caloric intake among young children with children consuming 25% more in the monsoon season compared to the spring season—attributed to greater availability of food post-harvest and change in meal patterns due to mothers sharing snacks with children while working in the field. Mother's work patterns, which varied by season, substantially impacted children's diets. She also noted a difference based on caste, with Kami (Dalit) children averaging higher intake of nutritious non-staple foods and higher overall energy intake than Tamang (Janajati) children overall. The relative difference was greater during the monsoon season. This was attributed to the different work patterns of the two castes. Tamang mothers worked in the fields, while Kami mothers remained at home enabling them to spend more time caring for the children. She noted similar caste differences and the association between women's work and children's energy intake in a second study as well. [45] During a case-control study of consumption practices associated with Xeropthalmia, Shankar et al. noted seasonal variation in consumption of vitamin-A rich vegetables, with lower consumption between the months of June and September. They also noted that households of higher socioeconomic status consumed more dairy compared to lower socioeconomic households.[46]

While evaluating a nutrition-sensitive agriculture that promoted livestock husbandry, Darrouzet-Nardi et. al. found that children in the mountains and Terai region had lower dietary

diversity during the pre-harvest season compared to the harvest season. They also found that the intervention had a more positive effect during the pre-harvest season.[13] Busert et al. conducted a longitudinal study of child growth in Jumla and noted that overall dietary diversity, and the percentage of children consuming vitamin A-rich fruits and vegetables and dairy was higher in May and July than in December.[32]

In an analysis of data from over 15,000 women in the Terai, Campbell et al. examined seasonality frequency of consumption of 31 different foods, including seasonal fruits and vegetables. She found that while the majority of women consumed rice, potatoes, lentils and vegetable oil twice a day, there was far less frequent consumption of fruits, vegetables and animal source food, particularly among women of low socio-economic status. Seasonal increase in consumption of seasonal fruits and vegetables occurred primarily among women of higher socio-economic status. She noted that consumption of mango peaked during July and August, with more than 50% of women consuming them only during those two months. [33]

In another study of 71 young children in Nepal's central hills, Panter-Brick [47] noted significant losses of weight during the monsoon season compared to the winter season which subsequently resulted in decreased growth velocity. This was attributed to the combination of a substantial increase in illness and poor diet during the monsoon season. Using nationally representative survey data, Mulmi et. al. noted a significant association between Nepali children's exposure to varying agroclimatic conditions while in utero and shortly after birth and their attained height. They also found that household sanitation and market access were protective, suggesting that both disease and changes in food availability were responsible for the observed relationship.

In a large study of pregnant women in the Terai, Jiang et al. [48] noted a high prevalence of micronutrient deficiencies which peaked during the summer and monsoon seasons. Hughes et al. [49] documented an association between season and birth outcomes during a large study in the Terai. Findings indicated that neonatal mortality was higher among babies born during the months of April-October and that outcomes including low birthweight and stillbirth followed seasonal patterns as well.

Notably, none of these studies compared seasonal differences across Nepal's three agro-ecological regions. One reason for the lack of greater attention towards seasonality within the agriculture-nutrition literature is researchers' tendency to primarily rely on data from large cross-sectional annual surveys.[42] The expense and time required to conduct such surveys prohibits collection of seasonal data. Conducting seasonal household surveys in surveillance sites across multiple regions offers a unique opportunity for examining seasonal variations.

2.3 Nutrition-Sensitive Agriculture Interventions in Nepal

To improve child (and maternal) nutrition status, integrated agriculture-nutrition interventions are increasingly being implemented across Nepal and in many other low-income countries. Such interventions take a wide variety of forms (reflecting the complex combination of factors that drive undernutrition), but nearly all include components that aim to improve the quantity and quality of foods accessible to a household by improving and diversifying production, and through income generation so that nutritious foods can be purchased.[14]

Although countless small food production and nutrition projects have long been implemented throughout Nepal, widespread implementation of large integrated programs began relatively recently. In 2012 the government released the "Multi-sector Nutrition Plan for Accelerating the Reduction of Maternal and Child Under-nutrition in Nepal."[50] Developed

through collaboration of the government, the NGO sector, large bilateral and multi-lateral donor agencies, and the research community, the document articulates a plan for bringing together efforts by the nutrition, agriculture, health systems, reproductive health, and sanitation and hygiene sectors. Around this time the government and international donor organizations launched several multi-sectoral nutrition initiatives, including *Suaahara*, *Kisan*, *Sunaula Hazar Din*, and the *Global Agriculture and Food Security Program*.[51]

Specific components of agriculture-nutrition initiatives in Nepal are greatly informed by the 2009 "Nepal Nutrition Assessment and Gap Analysis" report.[52] This document reviews determinants of undernutrition in Nepal and recommends interventions that the authors view as both feasible and evidence-based. One intervention model recommended are those that promote "improved" gardens and small livestock husbandry as a strategy for increasing availability of diverse foods and generating income. [15, 53-55] Improved gardens are those that produce multiple types of vegetables, fruits, and other crops on a year-round basis. Helen Keller International's (HKI) Homestead Food Production (HFP) model provides an illustrative example of programs of this type.[15, 56-58] Implemented in Nepal and several other low-income countries, HFP programs provide women with seeds and training in cultivation methods for improved gardens, in combination with inputs and training related to small animal husbandry. Evaluations of interventions following this model suggest that they improve the amount and diversity of nutritious foods produced and consumed by mothers and children.[14, 59]

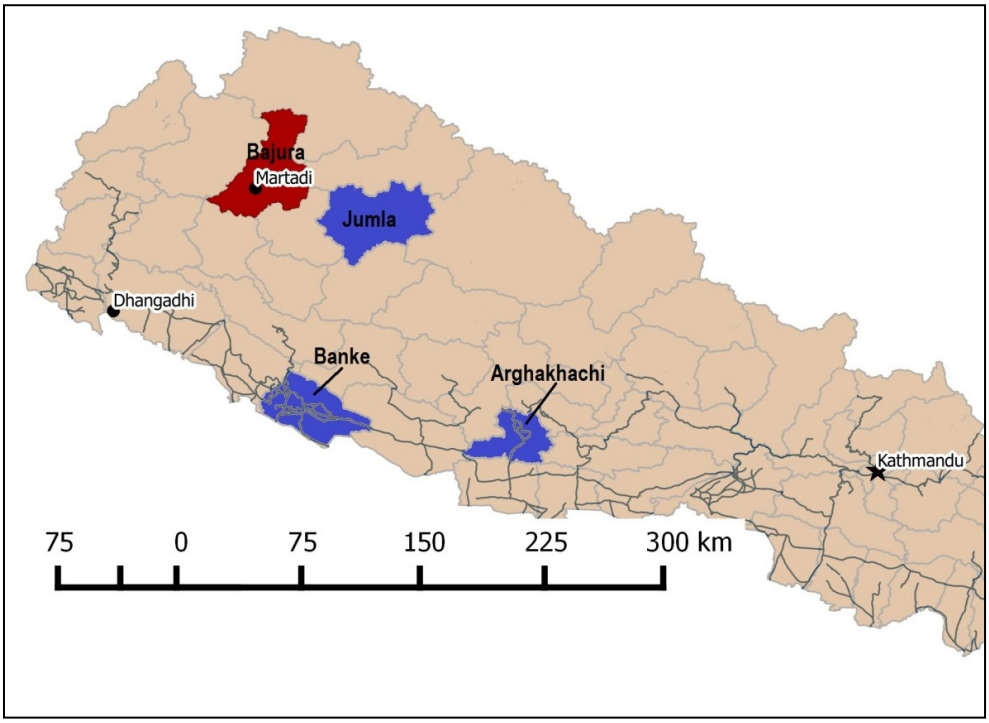
Numerous studies indicate contextual factors that are likely to affect implementation of nutrition-sensitive agriculture interventions in Nepal. For example, studies have shown that: caste and socioeconomic status influence food security and crop diversity;[60, 61] market access influences the relationship between crop diversity and household food self-sufficiency;[62] and

labor migration may reduce household cereal crop production. [63] Yet, most of these studies examine individual contextual factors in isolation, rather than considering the numerous ways they are intertwined.

2.4 Research Setting

Figure 2, below, displays a map of Nepal with the districts highlighted where data collection occurred. Quantitative survey data used in manuscripts one and two were collected in Jumla, Arghakhanchi, and Banke (blue). Qualitative data used in manuscript three were collected in the far-Western district of Bajura (red).

Figure 2. Map of districts in Nepal where study data were collected



Bajura lies in the far-Western mountains of Nepal, one of the historically most exploited and disenfranchised regions of the country.[64] It was also the scene of extensive Maoist activity and violent conflict during the civil war.[65] The majority of the population of about 135,000 are considered Chhetri, a higher-status caste group that historically held great power in this region.

Around one-third of Bajura's population are Dalit, a term that refers to the lowest status caste groups, which higher status groups traditionally referred to as "untouchable." The population also included some Brahmin (the highest status caste group) and Janajati (of Tibetan descent) communities.[66] Other than Janajati communities which speak Tibeto-Burman dialects, the population speaks a version of Nepali thought to be close to the original version of the language, referred to as "khas bhasa."[64] In this region, caste and gender-based power differences and discrimination persist to a greater degree than in much of the rest of the country.[64] Bajura's population is deeply impoverished and food insecure and currently has the lowest human-development index (HDI) score in Nepal.[67] The majority of households only produce enough food for three months or less, and stunting prevalence among children under five is well over 50%.[68]

Reaching the district headquarters of Bajura requires a plane ride from Kathmandu to Kailali district, and then a day and a half-long jeep ride along barely passable roads. During the rainy season when the Budhiganga River is too high to drive across, it then takes several hours of hiking to reach the headquarters, with the last hour or so up a cliff via steep tone steps. Basically, it is remote, and communities beyond the district headquarters are even more remote. Traveling between the district headquarters and far-flung communities can take up to three days of (fast) walking. Transporting food or goods requires donkeys. Few communities outside of the district headquarters have electricity or mobile phone service coverage.

Like Bajura, Jumla lies in Nepal's far-West mountains and shares similar terrain, climate and demographics. Additionally, it shares a history of impoverishment and food insecurity compounded by being heavily affected by the civil war.[64] Although Jumla's HDI score is above Bajura's it still ranks among the lowest in Nepal, and the estimated percentage of children under

five that are malnourished is above 50%.[67] Jumla's population of just under 109,000 is very similar to Bajura's regarding castes represented and languages spoken.[66] However, the district headquarters, Jumla Bazaar, is one of the largest and most prosperous market centers in the region, meaning there are substantial wealth disparities within the district. The PoSHAN study site borders the bazaar, with one cluster immediately adjacent to it and the other two about a half hour and hour-long walk away, respectively. All three are accessible by road, although in the summer landslides caused by the monsoon often make the road impassable.

Arghakhanchi lies in the Western hills of Nepal and ranks low within the top half of districts in Nepal according to HDI score, with approximately 30% of children under five malnourished.[67] In the Western hills, almost 40% of the population belongs to Hill Janajati groups (such as the Tamang and Gurung), nearly one-third is considered Brahmin, and the rest of the population is split roughly evenly between Chhetri and Dalit groups. Two-thirds of the population speak Nepali as their native language, and the rest speak other local languages.[1]

Banke lies in Nepal's mid-Western Terai and also ranks low within the top half of districts in Nepal according to HDI score, just below Arghakhanchi. Within the mid-Western Terai, approximately 45% of children under five are malnourished.[67] Nearly one-third of the population consists of Terai Janajati groups (such as the Tharu), and approximately one-fifth of the populations is considered Chhetri. The rest of the population is roughly evenly divided between Brahmin, Dalit, and Hill Janajati groups, with a small Muslim population as well. Approximately half of the population speaks Nepali as their native language. The majority of the rest speak Bhojpuri, Maithili or indigenous dialects as their native languages.[1]

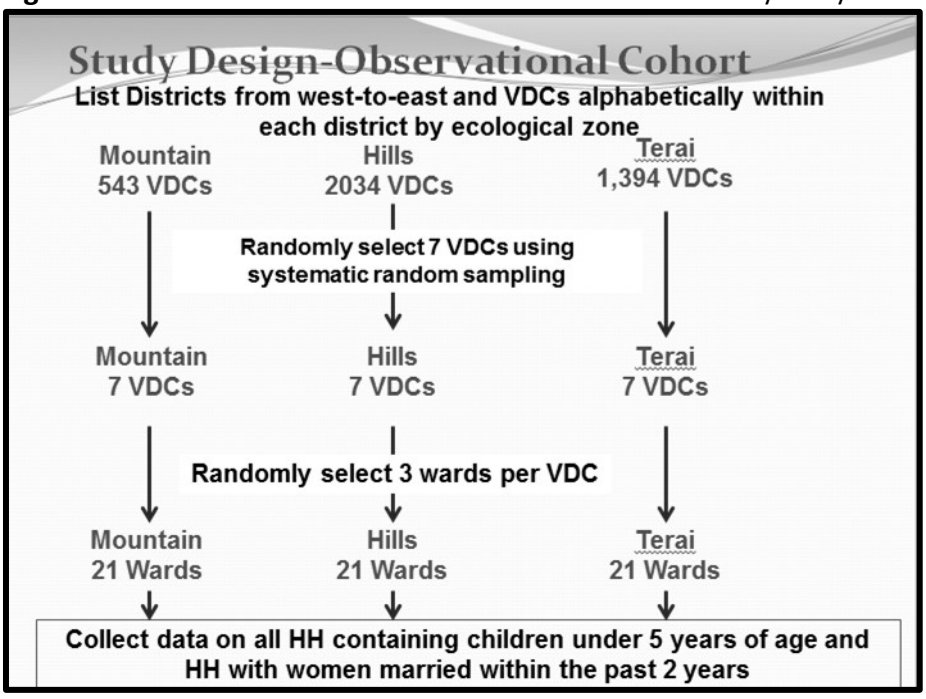
Chapter 3. Methods

3.1 Data Sources

3.1.1 The PoSHAN Nutritional Surveillance System

Quantitative analyses described in manuscripts one and two used data from the Nepal Nutrition Innovation Lab's Policy and Science of Health, Agriculture and Nutrition (PoSHAN) community study that began in 2013. The goal of the PoSHAN (meaning nutrition in Nepali) study is to "assess and monitor co-variations in household food security, dietary intake and nutritional status of preschool aged children and their mothers using measures of agricultural diversity, local market food prices, and exposure to agricultural, microcredit, nutrition, and health programs in Nepal."[69] Figure three displays a schematic of how PoSHAN sites were selected. Village development committees (VDCs), Nepal's second smallest administrative unit, were the primary sampling units for the first stage of selection. Wards, Nepal's smallest administrative unit, were the primary sampling units for the second stage of selection.

Figure 3. Schematic of site selection for the PoSHAN community study



Nested within the 21-VDC PoSHAN annual survey sample, three districts were designated as sentinel surveillance site locations. Selected districts were Jumla, Arghakhanchi, and Banke, representing the mountains, hills, and plains regions respectively. Within sentinel sites, all households with children five and under and with recently married women were surveyed three times a year between 2013 and 2015. Data collection occurred during the rainy season in June or July, just after the rainy season in September, and during the dry season in either January or February. The first sentinel site survey round included 507 households and a total of 571 children aged five and under. Data collected included maternal and child nutritional status indicators and a 7-day dietary recall, agricultural and livestock production and income generated, local market prices and expenditure data for a detailed list of common food items, women's level of control over household agricultural and economic decisions, as well as detailed socioeconomic information. Seven rounds of data collection in total were conducted, and annual survey data continue to be collected, although the additional two seasonal data collection rounds were discontinued.

Surveys included a module to collect data on mothers' and children's seven-day dietary intake using a food frequency questionnaire (FFQ) designed for use in Nepal. [33] Data collectors administered the FFQ by asking mothers to report how many times their child consumed each of 31 commonly eaten foods in the seven days prior to the survey. Surveys also include questions on individual and household demographics, house construction materials, asset ownership, livestock ownership, and crop production.

3.1.2 Qualitative Implementation Research

In collaboration with Helen Keller International (HKI), I collected qualitative data examining the implementation of HKI's homestead food production (HFP) program in Nepal's

far-West Bajura district. I collected data between December 2013 and March 2014, employing several of the methods recently recommended by Menon et al.[19] Specifically, I conducted interviews with mothers participating in the program (31) and program staff (11), and conducted focus group discussions (FGDs) with FCHVs (3 FGDs, 28 respondents). I also shadowed program staff while they conducted program activities throughout the district.

Interviews with mothers and FGDs with FCHVs followed semi-structured guides (see Appendix 1 for topics covered). Mothers of children under 5 who were HFP participants were recruited for interviews with the help of program staff. FCHVs were recruited for FGDs during program training events. I conducted interviews and FGDs in Nepali with assistance from program staff members who were also familiar with the local dialect (a version of Nepali[70]). For program staff interviews, I developed a separate set of questions for each respondent depending on their position and expertise. I conducted these interviews in a combination of Nepali and English. Interviews and FGDs were recorded, then transcribed and translated by two Kathmandu-based research assistants.

Staff members shadowed included the nutrition officer, the agriculture officer, and the water, sanitation and hygiene officer. I took extensive field notes on all activities observed, and the communities and environments we traveled through. I also took detailed notes on and photographs of home gardens and poultry in each community visited.

3.2 Ethics

Both the PoSHAN community study and the implementation research conducted with HKI were approved by the institutional review board (IRB) at the Johns Hopkins Bloomberg School of Public Health (JHSPH) and the Nepal Health Research Council. The data collection agency New

Era provided research ethics training to the PoSHAN team of interviewers and supervisors.[71] All study participants provided verbal informed consent. I also took additional steps to ensure that data collection in Bajura was conducted ethically. Due to my association with the HFP program, I was concerned that women would feel pressured to agree to participate in an interview even if they were very busy with other work, or felt uncomfortable with the situation. During the informed consent process, I therefore clarified that their decision regarding participation in the interview would have no impact on their program participation. I also paid careful attention to women's demeanor during the interview, ending it early if they seemed reluctant, hesitant, or busy with other work. Another ethical concern was ensuring that I did not inaccurately raise expectations regarding my role within the program and what the program could provide. I therefore explained prior to each interview that I was a student and was not employed by the program. I explained that I would use the information that they provided to prepare a report for the program staff in Kathmandu.

3.3 Quality and Rigor

Prior to initiating data collection, the PoSHAN study team pretested all data collection instruments in two different non-study areas.[71] The data collection agency New Era, which has extensive experience conducting the Demographic and Health Survey in Nepal, provided the field team of interviewers and supervisors with five weeks of intensive training. The training covered interview procedures, technique, and standardization. Interviewers had to demonstrate proficiency in all aspects of survey administration in order to proceed on to field work.[71] During data collection, field team supervisors and central New Era office staff conducted systematic quality control checks. These included checking of all completed surveys for consistency and accuracy, conducting re-interviews with a subset of all study participants and checking for

consistency, and providing data collectors with feedback and mentorship regarding their survey administration technique.[69]

Drawing on Lincoln and Guba's[72] evaluative criteria for establishing the trustworthiness of research findings, I used several strategies to enhance the quality and rigor of the qualitative data collected. First, including different groups of respondents (program participants, staff, FCHVs) allowed me to critically compare the information that they provided. This triangulation of findings enhanced the credibility and confirmability of findings. The multiple months that I spent at the study site and the ongoing observations that I recorded throughout further contributed to credibility. To enhance dependability, I wrote extensive memos regarding reflexivity and observed reactivity throughout the data collection process. I took these memos into account during the analysis process, and used a coding framework that made explicit my theoretical perspective and the inductive themes identified. Additionally, I conducted member-checking of preliminary findings with multiple levels of program staff. Finally, the thick descriptions of context preserved in the analysis write-up enhanced transferability of the study's findings and conclusions.

Chapter 4. Seasonality of consumption of non-staple micronutrient-rich foods among young children from three agroecological zones in Nepal

4.1 Abstract

Background: Improving young children's nutritional status requires improving diet quality year-round. Yet most data collected on diet quality is cross-sectional, obscuring variations that may occur seasonally. We need a better understanding of the seasonal patterns of children's consumption frequency of micronutrient-rich foods, and the extent to which these patterns differ geographically and demographically. Nepal's ecological and sociocultural diversity make it optimal for examining seasonality across different contexts.

Objectives: To examine seasonal differences in children's consumption frequency of vitamin A-rich fruits and vegetables, dairy products, eggs, and flesh foods (meat, fish, and poultry) in communities located in each of Nepal's three agroecological regions and assess whether seasonal consumption patterns vary by wealth and caste/ethnicity.

Methods: Using longitudinal data from the Policy and Science for Health, Agriculture, and Nutrition (PoSHAN) Community Studies seasonal surveillance sites in Nepal's three agroecological regions, we analyzed seven-day food frequency questionnaires collected three times per year for two years between May 2013 and February 2015 from children 6-72 months in the mountains (Jumla, N=226), hills (Arghakhanchi, N=168), and lowland plains, referred to as the Terai (Banke, N=225). For each food group, we calculated summary statistics and the relative contribution of individual foods to total consumption by season and region. We then fit multivariate negative binomial models to estimate the relationships of season, wealth, and caste/ethnicity with consumption frequency, including interactions between season and wealth, and season and caste/ethnicity when indicated by fit indices. Finally, we calculated and plotted

the average adjusted predicted consumption frequencies for each food group across seasons, wealth levels, and caste/ethnicity groups.

Results: Overall, results characterize young Nepali children's diets as very low in micronutrient-dense foods year-round. Analyses indicated significant seasonal differences in children's weekly consumption frequency of: vitamin A-rich fruits and vegetables in Jumla and in Banke ($p < 0.001$), with evidence of moderation by wealth in Jumla ($p < 0.001$); of dairy products in Arghakhanchi ($p < 0.001$) and in Jumla, with evidence of moderation by caste in Jumla ($p < 0.004$); and of meat and fish in Banke ($p < 0.001$), with evidence of moderation by caste/ethnicity ($p < 0.004$).

Conclusions: Overall, these findings emphasize Nepali children's low consumption frequency of micronutrient-rich foods and the need for program planners to be watchful for and responsive to seasonality. Seasonal variations in young children's consumption of non-staple nutritious foods may result in poorer diet quality at certain times of year and among certain population groups, but also may indicate positive trends that could be promoted more widely. More widespread and long-term collection of seasonal dietary intake data is needed so that future analyses can assess the generalizability of these findings to other areas and over longer time spans. Our findings also emphasize the need for researchers to consider the way timing of data collection may mask or accentuate deficiencies in diet quality and disparities between groups.

4.2 Introduction

Nepal's efforts in the health sector over the past decade have dramatically reduced infant and child mortality; however, the challenge of undernutrition persists. Along with protein-energy malnutrition, micronutrient deficiencies pose a critical problem among children in Nepal.[4] A 2014 study by Schulze et al. found that among a sample of 1000 children between six and eight years old, nearly 92% experienced at least one micronutrient deficiency, and nearly

65% experienced multiple deficiencies.[5] The quality of a child's diet, particularly the diversity of foods consumed, is a crucial determinant of micronutrient status as well as overall nutrition status.[6, 27] Numerous studies have documented the strong association between dietary diversity and children's micronutrient intake in low-income countries.[73, 74] A recent longitudinal study by Busert et al. indicated that increasing dietary diversity not only reduced Nepali children's risk of stunting, but also promoted catch-up growth after growth faltering,[32]

Child dietary diversity indicators validated by the World Health Organization and USAID's Food and Nutrition Assistance Technical Program sum consumption across seven different categories: 1) grains, roots, and tubers; 2) legumes and nuts; 3) dairy products; 4) flesh foods; 5) eggs; 6) vitamin-A rich fruits and vegetables; 7) other fruits and vegetables. Four of these categories—dairy products, flesh foods, eggs, and vitamin-A rich fruits and vegetables—are of particular importance because they are micronutrient-dense, yet often infrequently consumed by children in low-income settings, including Nepal.[35-39] Many nutrition programs now aim to increase children's consumption frequency of foods within these four groups, and to promote agriculture strategies that can increase year-round household access to non-staple nutrient-rich foods.[9-13]

Understanding seasonal patterns in children's consumption frequency of key food groups can provide valuable information regarding challenges to and opportunities for improving year-found diet quality. In subsistence agriculture settings diets change substantially throughout the year due to shifting climactic patterns that determine timing and yields of staple and non-staple crop production, availability of feed for livestock, and availability and cost of foods in the market. Numerous studies from Nepal document changes in children's weight and growth rate that correspond to decreased availability of staple grains during the pre-harvest lean season and

increased availability of staple grains during the post-harvest season, as well as to seasonal variations in illness prevalence and women's agricultural work.[31, 32, 47, 75, 76] However, only a few studies have examined the seasonality of consumption of the micronutrient-rich non-staple foods that are critical for diet quality. Among Nepali women, studies indicate seasonal differences in micronutrient status[48] and in consumption frequency of certain fruits and vegetables[33] in the Terai region. Among Nepali children, a study conducted in the mountains noted seasonal differences in the consumption of vitamin-A rich fruits and vegetables and dairy products[32] and a study conducted in the Terai noted seasonal differences in the consumption of vitamin-A rich fruits and vegetables,[46] although these were not the focus of either study. A recent nutrition-sensitive agriculture program evaluation found that children's dietary diversity differed significantly by season, and that the program had a larger impact during the pre-harvest season when dietary diversity was lowest.[13] These studies' findings and those from similar studies conducted in Bangladesh[77, 78] indicate that seasonal differences in Nepali children's consumption frequency of key micronutrient-rich foods deserve further attention.

Moreover, effective targeting of programs and strategies requires understanding how seasonality may differ across Nepal's environmentally and socioculturally diverse landscape. Rainfall and temperatures vary widely throughout the year and between regions in Nepal. According to the Food and Agriculture Organization,[79] over 80% of annual rainfall occurs during the monsoon season, between June and September. The timing and amount of rainfall differs from North to South, with the mountains region in the North receiving the least precipitation, the mid-Hills area receiving the most, and the Terai region (lowland plains) usually receiving somewhat less than the Hills. The driest and coldest time of year occurs during January and February, when temperatures in the mountains reach below freezing and in the Terai average around 60 degree Fahrenheit. The hottest time of the year occurs just before the monsoon

starts, with temperatures in the Terai commonly reaching above 100 degrees, those in the hills averaging around 80 degrees, and mountain temperatures varying dramatically depending on altitude. Given this variability, food production trends differ substantially throughout the year and between regions. Additionally, livelihoods, ability to purchase foods, and access to resources needed for food production, including land and water, differ substantially by region, wealth, and caste/ethnicity.[80-82] Food preferences, restrictions, and child feeding practices also vary by region and caste/ethnicity.[31, 34, 83, 84] Seasonal variations in children's diets may differ based on these economic, and cultural factors.

This analysis therefore aims to: 1) examine seasonal differences in children's consumption frequency of key micronutrient-rich foods across Nepal's three agroecological regions; and 2) assess whether these seasonal patterns vary by wealth and caste/ethnicity.

4.3 Methods

4.3.1 Description of the PoSHAN data collection system

Data used in this analysis were collected as part of the Policy and Science for Health, Agriculture, and Nutrition (PoSHAN) community studies in Nepal. Started in 2013, the PoSHAN data collection system conducts yearly panel surveys to assess and monitor household food security, dietary intake and nutritional status among preschool aged children and their mothers living in twenty-one sites selected to be representative of Nepal's three agroecological regions. Within each of these twenty-one sites, PoSHAN conducts annual surveys among all eligible households located in three geographic clusters per site. Clusters are based on wards, Nepal's smallest political administrative unit, and were randomly selected from a list of all wards within each site. Eligible households include those with a newly married woman, a pregnant woman, or a child under five during the first year of data collection or under six thereafter. PoSHAN surveys

include a module to collect data on mothers' and children's seven-day dietary intake using a food frequency questionnaire (FFQ) designed for use in Nepal. [33] Data collectors administer the FFQ by asking mothers to report how many times their child consumed each of 31 commonly eaten foods in the seven days prior to the survey. Surveys also include questions on individual and household demographics, house construction materials, and asset ownership, among many other topics. Annual surveys are conducted during the months of May, June and July each year (referred to here as the summer season).[69, 71] Ethical approval for the PoSHAN community studies is granted by the institutional review board at the Johns Hopkins Bloomberg School of Public Health and from the Nepal Health Research Council.

4.3.2 Seasonal surveillance sites

At three of the PoSHAN data collection sites, one per agroecological region, households were surveyed three times per year between 2013 and 2015 to capture possible seasonal variations in food security, diet, and nutritional status. These surveillance sites were selected by comparing publicly available demographic, economic and agricultural statistics for all sites within each agroecological region and then identifying the site with values closest to the average [71]. The three selected sites were located in the districts of Jumla in the mid-Western mountains, Arghakhanchi in the Western hills, and Banke in the mid-Western Terai.

After annual surveys were conducted at all PoSHAN sites during the summers of 2013 and 2014, households in the seasonal surveillance sites were surveyed two more times: during the fall (September 2013, September 2014) and the winter (January and February 2014, January and February 2015). Data collection during the fall and winter required four to six weeks to complete and, at all three sites, data collection during the second year started and ended within 10 days of the first year's start and end dates for these seasons. Data collection during the summer

required six to eight weeks due to the annual survey's longer length. Summer data collection during the second year started and ended earlier than the first year's start and end dates; in Jumla and Banke the difference was greater than 20 days. This meant that more observations during the first summer occurred after the start of the monsoon, and more observations during the second summer occurred prior to the start of the monsoon.

4.3.3 Analytic sample

Seasonal data collection between summer 2013 and winter 2015 yielded a total of 3,790 surveys administered (referred to from this point on as observations) to a total of 857 children in 621 households. About half of the 857 children were surveyed at all six timepoints. The table in Appendix 2 summarizes the reasons for incomplete panels among the other half. The primary reason was child age, i.e. the child was either born partway through the two-year span, or became too old to be eligible for the study.

Of the 3,790 total observations, 2,700 observations from 619 children were included in this analysis: 897 observations from 226 children at the Jumla site, 787 observations from 168 children at the Arghakhanchi site, and 1015 observations from 225 children at the Banke site. Figure 4 shows how these observations were selected from the full dataset. First, observations where children were below six months of age or that did not meet date criteria were removed. Date criteria were imposed to ensure that observations for each season were from approximately the same time span for both years. As noted above, data collection started earlier in summer 2014 compared to summer 2013. Therefore, second year observations that occurred more than 10 days before data collection began the first year, or first year observations that occurred more than 10 days after data collection began the second year were removed. This resulted in removal of 147 observations from Jumla and Banke; the total number of children

remained the same. One index child per household was then selected, and observations for non-index children were removed. In households with more than one child, the child with the most observations was considered the index child. In cases where two or more children in a household had the same number of observations, the index child was selected randomly. Table 1 provides characteristics for all children included in the analysis sample at each of the three sites.

4.3.4 Analysis variables

Outcome variables were children's reported seven-day consumption frequency of vitamin A-rich fruits and vegetables, eggs, dairy, and meat and fish. Each was constructed by summing the reported seven-day consumption frequencies of individual foods on the FFQ that fell into each category. For vitamin A-rich fruits and vegetables this included dark green leafy vegetables, carrots, pumpkin, ripe mango, jackfruit, and papaya. Dairy included milk and yogurt. The category of meat and fish included chicken, goat, buffalo, pork, large fish, dried fish, and small fish.

The primary independent variable was season of data collection (summer, fall, or winter). Secondary predictor variables were wealth and caste/ethnicity. Wealth was characterized by conducting a principle components analysis (PCA) using survey questions regarding house construction materials and household asset ownership, generating a score for each household based on PCA factor loadings, and then dividing the population into tertiles based on those scores. [85] The PCAs were conducted separately by agro-ecological zone as house construction materials and types of assets owned vary by zone. Caste/ethnicity was initially categorized using the groupings defined by the Nepal government for use in the national health management information system: Dalit, Disadvantaged Janajati, Disadvantaged Terai Castes, Religious

Minorities, Advantaged Janajati, and Upper Caste. [86] For analysis purposes, several of these categories were then combined. At the Jumla and Arghakhanchi sites the majority of the population were either Upper Caste or Dalit, so these were designed as Group 1 and Group 2, and children of any other caste or ethnicity were designated as Group 3. At the Banke site, the two major groups were Disadvantaged Terai Castes and Religious Minorities, and again all other castes or ethnicities were categorized as Group 3.

Cluster and year of data collection were included in multivariate analyses to adjust for potential unobserved geographic and time-related factors influencing consumption. Child age was also included to adjust for the difference in average age across data collection rounds due to the change in age cut-off from five years during year one to six years during year two. Child gender was not included as the gender breakdown did not differ significantly across data collection rounds and preliminary bivariate analyses indicated gender was not significantly related to consumption frequency for any of the food groups.

4.3.5 Statistical analysis

Statistical analysis consisted of first examining outcome distributions and descriptive statistics, selecting an appropriate modeling approach based on outcome distributions and study design features, running a series of models for each outcome and comparing fit, selecting and then checking a final model of best fit for each outcome with diagnostic plots, and finally calculating and plotting marginal values for each model to aid in interpretation. All analyses were conducted separately for each of the three sites. Analyses were conducted in Stata 14.[87]

Visualization of outcome distributions with histograms and boxplots and examination of descriptive statistics indicated heavily right-skewed distributions and substantial over-dispersion (variance greater than the mean) for all outcomes. We therefore selected negative binomial

regression with random intercepts for each child as a modeling method.[88, 89] All models were run using Stata's menbreg command with a constant dispersion parameter option (as constant dispersion yielded superior or equivalent fit for all models compared to mean dispersion). [90]

Descriptive statistics (mean, standard deviation, median, inter-quartile range, range, and percent missing values) were calculated for each outcome overall and by categories of the three predictor variables of interest. There were no missing values for predictor variables. Outcome variable counts were missing for only three children. During analysis, these were handled through Stata's default of case-wise deletion.

We ran a series of multivariate models for each outcome, adjusting for: geographic cluster, year of data collection, and child's age in months. For each outcome we first ran a base model that included the three predictor variables of interest, followed by models including an interaction between season and wealth tertile, an interaction between season and caste/ethnicity group, and finally both interactions. The four models were then compared using log-likelihood, Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC), and the likelihood ratio test (comparing each of the three models containing interactions to the base model, and models with one interaction to the model with both interactions). Interaction terms were only retained if they resulted in a substantial improvement in fit.

The model with the best fit indices for each outcome was then selected and assessed for suitability by calculating deviance residuals and plotting them against predicted values and against each predictor variable in the model. The bulk of residuals were clustered around zero for all diagnostic plots, indicating adequate fit.[89] Outcome values associated with outlying derivatives were examined for plausibility (i.e. an amount that could have feasibly been consumed, rather than data entry error) and models were run with and without outlying values

to assess the sensitivity of results. No implausible values were identified, and estimates and significance levels from models run without outlying values differed little from previous estimates, so all outliers were retained. Final models were then run with robust standard errors to account for any model miss-specification. Confidence interval estimates and significance levels differed only slightly, indicating models were correctly specified, however results produced by the models with robust standard errors are presented as the final models to be conservative. Additionally, to correct for the multiple hypotheses being tested, a Bonferroni correction was used to adjust the significance threshold when interpreting model output. The standard p-value of 0.05 was divided by twelve to account for the twelve different analyses (four different outcomes being tested separately for each of the three sites), yielding an adjusted significance threshold of 0.004.

Finally, using the fixed effects portion of each model we calculated and plotted average adjusted predictions and calculated average marginal effects by season using Stata's margins and marginsplot commands.[90] Additionally, when models indicated significant differences by wealth or caste/ethnicity and/or interactions between these variable and season, we calculated and plotted average adjusted predictions by season disaggregated by wealth or caste/ethnicity group. These marginal values were used to facilitate interpretation of raw model output by translating the estimated incident rate ratios into approximate differences in consumption counts between seasons or groups.

4.4 Results

4.4.1 Descriptive statistics

Children's consumption frequencies of non-staple nutritious foods were very low overall. Table 2 provides descriptive statistics for each of the four food groups at each study sites. On

average, children at all three sites consumed vitamin A-rich fruits and vegetables fewer than five times in the seven days prior to the survey, and consumed eggs or meat and fish less than twice. In Arghakhanchi, children consumed dairy slightly more than 10 times on average in the seven days prior to the survey, while in Jumla and Banke children's mean seven-day dairy consumption frequency was less than five and four times respectively. Median consumption frequencies were substantially lower than means for all outcomes, indicating heavily right-skewed distributions.

The types of vitamin A-rich fruits and vegetables and meat and fish that children consumed differed by season and by region. Mean consumption frequencies by season for the individual foods within each food group are displayed as stacked bar charts in Figure 5, and the bar charts in Figure 6 show the percentage each individual food comprises of all instances of consumption of that food group by season. Dark green leafy vegetables had the highest mean consumption frequencies and comprised the majority of vitamin A-rich fruits and vegetables consumed at all sites and timepoints, with the exception of the summer season in Banke, where mangoes comprised 84% percent of consumption. Milk made up the majority of all dairy consumption; yogurt contributed slightly more to dairy consumption in Arghakhanchi (16-19%) than in Jumla or Banke (4.2-16% and 7-13%). Types of meat and fish consumed varied substantially by site, with goat comprising the majority of consumption in Jumla (40-51%) and poultry comprising the majority in Arghakhanchi (54-67%). Poultry also made up the majority of consumption in Banke in the summer and winter (53% and 61%), but in the fall fish contributed to 75% of all consumption and to the higher mean consumption of meat and fish in Banke at that time.

4.4.2 Multivariate analyses

The four sub-sections below describe the multivariate analysis results for each of the four food groups. Table 3 presents the final models for children's consumption of vitamin A-rich fruits and vegetables in each region. Table 4 presents the final models for children's consumption of each type of animal source food in each region. These tables display estimated incident rate ratios (IRR), 95% confidence intervals (CI), and significance levels for each model's coefficients and constant terms. Figures 7-11 display marginal plots—i.e. estimated outcome variable values calculated using model coefficients. These plots show average adjusted predicted mean weekly consumption by season, and by caste/ethnicity or wealth. Each point is generated by calculating the mean weekly consumption frequency of all children at a given timepoint and within a given caste/ethnicity or wealth group while averaging over all over model coefficients.

Vitamin A-Rich Fruits and Vegetables

Final models (Table 3) and average adjusted predictions calculated from those models indicate significantly lower weekly vitamin A-rich fruit and vegetable consumption frequency during fall and winter compared to the summer in Jumla, and significantly lower consumption during the fall compared to the summer or winter in Banke ($p < 0.001$). As shown in Figure 7, all other variables being the same, in Jumla the fall and winter seasons are associated with children consuming vitamin A-rich fruits and vegetables an average of slightly over two fewer times per week compared to the summer. In Banke, the fall season is associated with children consuming them almost three times fewer per week than in the summer or winter. In Arghakhanchi, there was no significant association between season and consumption of vitamin A-rich fruits and vegetables.

In Jumla, the final model suggests significant interaction between season and wealth. Interaction term estimates indicate that although there were no significant differences in consumption frequency by wealth quintile during the summer or fall, in the winter children from households in the middle wealth tertile compared to the top wealth tertile were 50% less likely to consume vitamin A-rich fruits and vegetables ($p < 0.001$). After disaggregating by wealth tertile, as shown in Figure 8, predicted mean consumption in the winter among children in the top wealth tertile was about four times per week, while it was less than two times per week among children in the middle wealth tertile. Estimates for the base and interaction terms for low wealth versus high in Jumla were non-significant. Base and interaction terms for caste/ethnicity group three, "other," were also significant, indicating decreased consumption compared to upper-caste children in the summer and winter and increased consumption in the fall, however given the small number of children from this group within each timepoint ($N < 20$), these findings should be interpreted with caution (and for this reason no average adjusted predictions were calculated or plotted for this group).

Eggs

Analysis findings (Table 4) suggest no significant associations between season and children's consumption of eggs at any of the three sites, or significant interactions between season and wealth or caste/ethnicity. In Banke, however, children in religious minority households were over twice as likely as children from disadvantaged non-Dalit Terai groups to consume eggs in the week prior to the survey ($p < 0.001$). As shown in Figure 9, all other variables being the same, this equates to predicted mean consumptions of about once per week among children from religious minority families, and less than 0.5 times per week among children from disadvantaged Terai caste households. Average adjusted predictions for the

caste/ethnicity groups other than religious minorities and disadvantaged Terai castes were not calculated due to the small number of children in this group.

Dairy

Regression analysis results (Table 4) and average adjusted predictions (Figure 10) suggest significantly higher dairy consumption in the fall and winter compared to the summer in Arghakhanchi ($p < 0.001$), and significantly lower consumption in the winter compared to the fall in Jumla ($p < 0.004$). In Arghakhanchi, all other variables being the same, fall was associated with children consuming dairy nearly four more times per week on average compared to the summer, and winter was associated with children consuming dairy just over 3.5 more times per week on average compared to the summer. There were no significant differences in dairy consumption by season in Banke.

In Jumla, there was evidence of interaction between season and caste/ethnicity group; being a child from a Dalit household in the winter was associated with a 70% lower consumption frequency ($p < 0.004$) compared to the summer and to children from upper-caste households. As shown in the top left plot in Figure 10, Dalit children's predicted mean dairy consumption in the winter was about two times per week lower than that of Upper-Caste children, while in the summer Dalit children's predicted mean consumption was still lower than that of Upper-Caste children, but the difference was non-significant.

There were significant associations between wealth and caste/ethnicity and dairy consumption frequency in both Arghakhanchi and Banke, although no significant interactions with season. In Arghakhanchi, being in the lowest wealth quintile compared to the highest was associated with a 40% lower consumption of dairy ($p < 0.001$), equivalent to a difference in predicted means of a little over three fewer times per week in the summer and about five fewer

times per week in the fall and winter, as shown in the middle right plot in Figure 10. In Banke, children in the lowest wealth quintile consumed an estimated 50% less dairy ($p < 0.001$), or a difference in predicted means of about 1.5 fewer times per week in the summer and winter and two fewer times per week in the fall, as shown in the lower right plot in Figure 10. Children from Dalit households and "other" households in Arghakhanchi consumed an estimated 50% and 40% lower dairy consumption frequencies respectively compared to children from upper caste households ($p < 0.001$). As shown in the middle left plot of Figure 10, that is equivalent to a difference in predicted means ranging from over three to nearly seven fewer times per week depending on season for Dalit children compared to upper-caste children and from three to just over five fewer times per week for "other" children compared to upper-caste children. In Banke, children from religious minority households were 60% less likely to consume dairy compared to children from Terai caste households ($p < 0.001$), equivalent to a difference in predicted means of about two fewer times per week, depending on season.

Meat and Fish

Regression analysis results (Table 4) and average adjusted predictions by season indicate significant differences in children's consumption of meat and fish in Banke alone, with greater consumption frequency in the fall compared to the summer ($p < 0.004$). As shown in Figure 7, this is equivalent to a difference in predicted mean consumption of about one time per week. Regression results also indicated significant interaction between caste/ethnicity and season in Banke. Disaggregating by caste/ethnicity, as shown in the lower plot in Figure 11, suggests that children from religious minority households eat slightly more meat and fish than children from Terai caste households in the summer and winter (a difference in predicted means of less than one time per week), but eat substantially more in the fall (a difference in predicted means of over two times per week). In Jumla, there was some evidence of interaction between season

and caste/ethnicity, with a significant interaction term for "other" caste/ethnicity during the fall. However, given the small number of children in this group, this finding should be interpreted with caution, and no average adjusted predictions were calculated.

In Arghakhanchi, children's consumption of meat and fish differed significantly by caste, although there was no evidence of interaction with season. Being from a Dalit household was associated with 60% great consumption frequency compared to being from an Upper-Caste household ($p < 0.001$). As shown in the upper plot in Figure 11, this is equivalent to a difference in predicted mean weekly consumption of about one time per week.

4.5 Discussion

Overall, analysis results characterize young Nepali children's diets as very low in nutritious foods. The possible exception is Arghakhanchi where consumption frequency of dairy products was substantially higher than in the other two sites, particularly during the fall and winter. Results indicate seasonal variations in consumption of vitamin A-rich fruits and vegetables, dairy, and meat and fish that differ across agroecological zones, and in some cases across socioeconomic groups. These findings concur with numerous previous studies regarding the inadequacy of diet quality for many children in Nepal.[13, 31, 47, 91] However, they also build on this existing literature by indicating site-specific seasonal differences and socioeconomic disparities in the consumption frequency of key food groups.

Consumption of vitamin-A rich fruits and vegetables peaked during the summer season in Jumla, and was lower in the fall and winter, particularly among poorer households. In Banke, average vitamin A-rich fruit and vegetable consumption was substantially lower, nearly zero, during the fall season, while in Arghakhanchi it was fairly even across all three seasons. Egg consumption did not seem to vary by season and was extremely low overall, within an

estimated average weekly consumption frequency of less than one in Arghakhanchi and Banke and less than 1.5 in Jumla. Dairy consumption was significantly lower during the winter in Jumla, but only among children from Dalit households. Estimated average consumption decreased during the winter for upper-caste children as well, however the difference was not statistically significant. In Arghakhanchi, consumption of dairy products decreased during the summer but was still much higher than in Jumla or Banke. In Banke dairy consumption was quite low at all three timepoints. Like eggs, consumption frequency of meat and fish was very low overall, with an estimated average of less than two times per week across all regions and seasons. It only differed significantly by season in Banke where, interestingly, consumption frequency increased substantially among children from religious minority (in this case Muslim) households during the fall.

To our knowledge, only two previous studies have examined similar outcomes among children in Nepal. Our findings regarding very low vitamin A-rich fruit and vegetable consumption during the summer in Banke concur with an older study by Shankar et al. which noted a decrease between the months of June and September in another Terai district.[46] Also in-line with our findings, Busert et al. noted decreased consumption of vitamin A-rich fruits and vegetables and dairy products during the winter in Jumla.[32]

No previous studies have specifically examined the interactions between season and wealth and caste/ethnicity in relation to children's dietary intake in Nepal. However, a study from Bangladesh found that seasonal differences in dietary diversity were greater in households of lower socioeconomic status,[92] and a study by Campbell et al. of women's consumption of seasonal food in Nepal found differences by socioeconomic status as well.[33] These lend plausibility to our findings from Jumla that decreases in consumption of vitamin A-rich fruits and

vegetables during the winter were greater among children from less wealthy households and decreases in dairy consumption during the winter were greater among Dalit children. We also noted wealth and caste/ethnicity-based differences in consumption across all seasons in some cases. In both Arghakhanchi and Banke, dairy consumption was significantly lower among Dalit children and among children from less wealthy households, likely due to the greater resources needed to own livestock and/or purchase milk in the market. Additionally, in Banke, children from Muslim households consumed more eggs compared to children from other Terai caste households and in Arghakhanchi Dalit children consumed more meat and fish compared to upper-caste children. Both of these findings are likely related to caste-related religious restrictions on consumption of certain animal source foods among Hindus.[83, 84]

The contribution of individual foods to overall consumption of each food group did not differ substantially by season, with the exceptions of vitamin A-rich fruits and vegetables and meat and fish in Banke. Mangoes constituted the bulk of vitamin A-rich fruits and vegetables consumed in Banke only during the summer, which concurs with Campbell et. al.'s study of seasonal food consumption by women in the Terai.[33] Fish, small fish to be specific, constituted the bulk of increased consumption of flesh foods only during the fall and primarily among children from Muslim households. This increased consumption of fish at one particular time point and among one particular group is an interesting positive trend that deserves further exploration.

We noted multiple limitations during this analysis. Foremost are limitations regarding generalizability. The fact that the seasonal data available covered only two full years makes it difficult to determine how generalizable these findings are over longer time spans. Also, although the seasonal surveillance sites were selected to be representative of their

agroecological regions, our specific findings should not be generalized to other sites within each region due to the diversity within regions and the multiple factors that influence seasonality. Other limitations include the earlier data collection start dates during the summer in year two, and the fact that the timespan of summer data collection includes two distinct weather patterns—the hot and dry pre-monsoon and the warm and rainy monsoon period. Additionally, data collection did not include information on quantities of consumption for each food, only frequency, so no conclusions can be drawn regarding nutrient intakes. Finally, children's consumption frequency data was based on report by their mother, so accuracy was likely effected by memory errors, and there is the possibility of social desirability bias.

Our findings emphasize the importance of examining seasonality. We need seasonal data collection over longer timespans and from a broader swath of locations across each agroecological region in order to develop a more complete and robust understanding of the seasonality of child diet quality in Nepal. Future research should also examine consumption quantity as well as frequency in order to understand the impact of season on nutrient intake, and further explore the intertwined environmental, social, and economic drivers of seasonal differences in order to design and target appropriate interventions.

4.6 Conclusion

Analysis of data collected over a two-year period at three sites in Nepal's mountains, hills, and Terai regions indicates significant seasonal differences in young children's consumption frequency of vitamin A-rich fruits and vegetables, dairy, and meat and fish at one or location. The magnitude and timing of differences varied substantially by site. Findings also suggest interaction between seasonal effects and wealth on consumption of vitamin A-rich fruits and vegetables and seasonal effects and caste/ethnicity on consumption of dairy products in Jumla,

and between seasonal effects and caste/ethnicity on consumption of meat and fish in Banke. More widespread and long-term collection of seasonal dietary intake data is needed so that future analyses can assess the generalizability of these findings to other areas and over longer time spans. Overall, these findings emphasize the need for program planners to be watchful for and responsive to seasonal differences in young children's consumption of non-staple nutritious foods that may result in poorer diet quality at certain times of the year and among certain population groups, or that may indicate positive trends that could be promoted more widely. They also emphasize the need for researchers to consider the way timing of data collection may mask or accentuate deficiencies in diet quality and disparities between groups.

4.7 Tables for Chapter 4

Table 1. Characteristics of PoSHAN study participants included in analysis by geographic area (back to text)

	Jumla (Mountains)	Arghakhanchi (Hills)	Banke (Terai)
Total Children (N)	226	168	225
Observations per child (N (%))			
One	14 (6.2%)	8 (4.8%)	10 (4.4%)
Two	38 (16.8%)	15 (8.9%)	20 (8.9%)
Three	46 (20.4%)	28 (16.7%)	36 (16.0%)
Four	29 (12.8%)	12 (7.1%)	20 (8.9%)
Five	40 (17.7%)	13 (7.7%)	57 (25.3%)
Six	59 (26.1%)	92 (54.8%)	82 (36.4%)
Geographic Cluster (N (%))			
One	128 (56.6%)	48 (28.6%)	102 (45.3%)
Two	50 (22.1%)	35 (20.8%)	73 (32.4%)
Three	48 (21.2%)	85 (50.6%)	50 (22.2%)
Caste/Ethnicity* (N (%))			
Dalit[2]	64 (28.3%)	53 (31.5%)	15 (6.7%)
Disadvantaged Janajatis[3]	7 (3.1%)	26 (15.5%)	11 (4.9%)
Disadvantaged Terai Castes[3]	1 (0.4%)	0 (0%)	100 (44.4%)
Religious Minorities[3]	3 (1.3%)	1 (0.6%)	85 (37.8%)
Advantaged Janajatis[3]	9 (4.0%)	18 (10.7%)	2 (0.9%)
Upper Caste[1]	142 (62.8%)	70 (41.7%)	12 (5.3%)
Wealth Tertile§ (N (%))			
High	76 (33.6%)	57 (33.9%)	68 (30.2%)
Medium	81 (35.8%)	54 (32.1%)	72 (32.0%)
Low	69 (30.5%)	57 (33.9%)	85 (37.8%)
Gender (N (%))			
Male	121 (53.5%)	100 (59.5%)	136 (60.4%)
Female	105 (46.5%)	68 (40.5%)	89 (39.6%)
Average Age in Months§ (Mean (SD))	29.2 (16.0)	28.6 (16.2)	29.4 (16.8)

*These were grouped for analysis: in Jumla and Arghakhanchi, Upper Caste was designated as Group 1, Dalit was designated as Group 2, and all other castes were designated as Group 3; in Banke, Disadvantaged Terai Castes were designated as Group1, Religious Minorities were designated as Group 2, and all other castes were designated as Group 3.

§At child's first observation

Table 2. Descriptive statistics for seven-day consumption frequency of each food type by geographic area (back to text)

	Children's Seven-Day Consumption Frequency			
	Mean (SD)	Median (IQR)	Range	n
Jumla (Mountains)				
Vit. A-Rich Fruits & Veg.	4.4 (5.9)	2 (0-7)	0-41	897
Eggs	1.8 (2.9)	0 (0-3)	0-21	898
Dairy	4.5 (6.7)	1 (0-7)	0-42	898
Meat & Fish	2.0 (2.5)	1 (0-3)	0-21	897
Arghakhanchi (Hills)				
Vit. A-Rich Fruits & Veg.	3.7 (3.8)	3 (1-5)	0-27	787
Eggs	1.0 (1.8)	0 (0-2)	0-14	787
Dairy	10.1 (9.5)	7 (1-16)	0-45	787
Meat & Fish	2.0 (2.1)	2 (1-3)	0-18	787
Banke (Terai)				
Vit. A-Rich Fruits & Veg.	2.4 (4.3)	1 (0-3)	0-36	1015
Eggs	1.0 (1.7)	0 (0-2)	0-14	1015
Dairy	3.3 (5.6)	0 (0-4)	0-35	1014
Meat & Fish	1.7 (3.0)	1 (0-2)	0-22	1015

Table 3. Multivariate negative binomial regression results for vitamin A-rich fruit and vegetable consumption showing estimated incident rate ratios (IRR) and 95% confidence intervals (95% CI) for models of best fit, adjusted for geographic cluster, year of data collection, and child age (back to text)

	Vitamin A-Rich Fruit and Vegetable Consumption		
	Jumla (Mountains)	**Arghakhanchi (Hills)**	**Banke (Terai)**
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Season			
Summer	1.0	1.0	1.0
Fall	0.5 (0.4-0.7)**	1.2 (1.0-1.4)	0.2 (0.1-0.2)**
Winter	0.7 (0.6-0.9)	1.1 (0.9-1.3)	1.0 (0.8-1.2)
Wealth			
High	1.0	1.0	1.0
Medium	0.9 (0.6-1.1)	0.8 (0.7-1.0)	0.9 (0.8-1.2)
Low	0.8 (0.6-1.1)	0.8 (0.7-1.0)	0.9 (0.7-1.2)
Caste/Ethnicity Group			
Group One[1]	1.0	1.0	1.0
Group Two[2]	0.7 (0.5-1.1)	1 (0.8-1.2)	0.8 (0.7-1.0)
Group Three[3]	0.4 (0.3-0.7)**	0.8 (0.7-1.0)	1.1 (0.9-1.4)
Season*Wealth Interaction			
Fall*Medium	1.0 (0.7-1.5)	--	--
Fall*Low	1.3 (0.9-1.9)	--	--
Winter*Medium	0.5 (0.3-0.7)**	--	--
Winter*Low	0.7 (0.4-1.1)	--	--
Season*Caste/Ethnicity Interaction			
Fall*Group Two	0.6 (0.4-0.9)	--	--
Fall*Group Three	2.6 (1.5-4.7)**	--	--
Winter*Group Two	0.5 (0.3-0.9)	--	--
Winter*Group Three	1.1 (0.6-2)	--	--
Constant	4.1 (2.5-6.6)**	1.6 (1.0-2.5)	1.6 (0.9-2.7)
*= p < 0.004; **= p < 0.001			

[1]Group One identifies Upper Caste households in Jumla and Arghakhanchi and Disadvantaged Non-Dalit Terai Castes in Banke

[2]Group Two identifies Dalit households in Jumla and Arghakhanchi and Religious Minorities in Banke

[3]Group Three identifies all "other" households for all three districts

Table 4. Multivariate negative binomial regression results for animal source food consumption showing estimated incident rate ratios (IRR) and 95% confidence intervals (95% CI) for models of best fit, adjusted for geographic cluster, year of data collection, and child age (back to text)

	Egg Consumption			Dairy Consumption			Meat and Fish Consumption		
	Jumla	**Argh.**	**Banke**	**Jumla**	**Argh.**	**Banke**	**Jumla**	**Argh.**	**Banke**
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Season									
Summer	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fall	0.9 (0.8-1.1)	0.9 (0.7-1.1)	1.2 (1.0-1.5)	1.3 (1.0-1.7)	1.6 (1.4-1.9)**	1.4 (1.1-1.7)	1 .0 (0.8-1.2)	0.8 (0.7-0.9)	1.6 (1.2-2.2)*
Winter	1.2 (1.0-1.4)	0.7 (0.5-1.0)	1.3 (1.1-1.7)	0.7 (0.5-1.0)	1.5 (1.3-1.8)**	0.9 (0.7-1.2)	1.0 (0.9-1.2)	0.9 (0.8-1.1)	1.0 (0.7-1.3)
Wealth									
High	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Medium	0.9 (0.7-1.2)	0.6 (0.4-0.9)	0.9 (0.6-1.1)	1.0 (0.7-1.5)	0.8 (0.7-1)	0.8 (0.5-1)	1.1 (0.8-1.4)	0.9 (0.7-1.1)	1.1 (0.8-1.5)
Low	0.9 (0.6-1.3)	0.6 (0.4-0.9)	0.7 (0.5-1.0)	0.6 (0.4-0.9)	0.6 (0.5-0.7)**	0.5 (0.3-0.7)**	1.1 (0.8-1.5)	0.8 (0.7-1.1)	0.7 (0.5-0.9)
Caste									
Group One[1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Group Two[2]	0.6 (0.3-0.9)	0.8 (0.5-1.3)	2.3 (1.5-3.5)**	0.5 (0.3-0.9)	0.5 (0.4-0.7)**	0.4 (0.3-0.6)**	1.1 (0.8-1.5)	1.6 (1.2-2)**	1.9 (1.2-2.9)*
Group Three[3]	1.2 (0.8-1.9)	1 .0 (0.6-1.4)	2.1 (1.3-3.3)*	0.6 (0.3-1.2)	0.6 (0.5-0.8)**	0.9 (0.6-1.4)	0.4 (0.2-0.8)	1.2 (1.0-1.5)	1.8 (1.0-3.1)
Season*Wealth									
Fall*Medium	--	--	--	0.9 (0.6-1.4)	--	--	--	--	--
Fall*Low	--	--	--	1.6 (1-2.7)	--	--	--	--	--
Winter*Medium	--	--	--	1.0 (0.6-1.8)	--	--	--	--	--
Winter*Low	--	--	--	1.0 (0.5-2.2)	--	--	--	--	--
Season*Caste									
Fall*Group Two	--	--	--	1.0 (0.6-1.7)	--	--	1.4 (1-1.9)	--	1.7 (1.1-2.5)*
Fall*Group Three	--	--	--	1.2 (0.5-2.7)	--	--	3.8 (2-7.5)**	--	0.8 (0.5-1.4)
Winter*Group Two	--	--	--	0.3 (0.1-0.8) *	--	--	1.4 (1.1-1.9)	--	1.3 (0.8-1.9)
Winter*Group Three	--	--	--	1.6 (0.7-3.8)	--	--	2.2 (1.0-5.0)	--	1.6 (1-2.5)
Constant	0.5 (0.2-1.1)	0.8 (0.4-1.8)	0.2 (0.1-0.5)**	5.5 (3.2-9.6)**	8.4 (5.2-13.7)**	2.5 (1.1-5.6)	0.6 (0.4-0.9)	0.8 (0.5-1.2)	0.2 (0.1-0.3)**
*= p < 0.004; **= p < 0.001									

[1]Group One identifies Upper Caste households in Jumla and Arghakhanchi and Disadvantaged Non-Dalit Terai Castes in Banke

[2]Group Two identifies Dalit households in Jumla and Arghakhanchi and Religious Minorities in Banke

[3]Group Three identifies all "other" households for all three districts

4.8 Figures for Chapter 4

Figure 4. Flow diagram showing selection of analysis sample from PoSHAN study population (back to text)

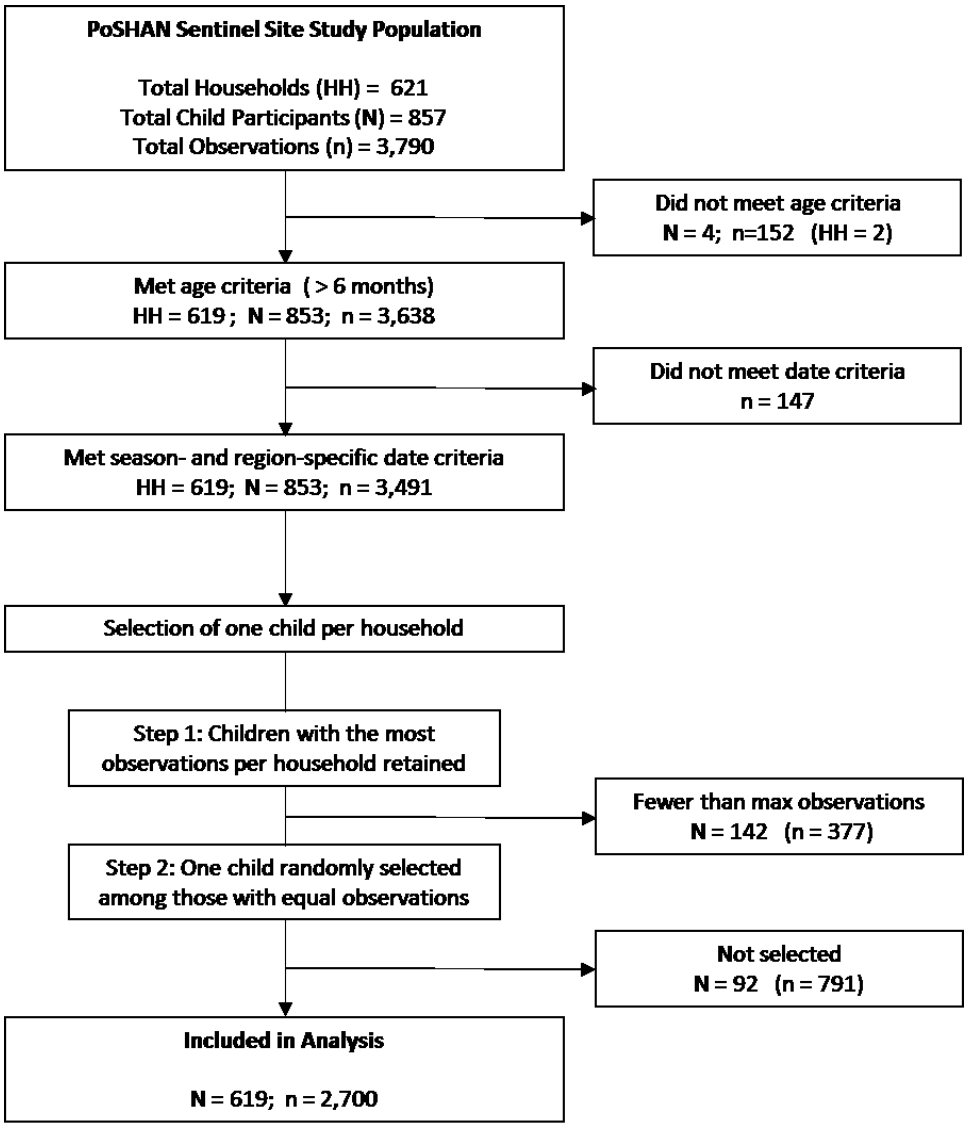


Figure 5. Children's mean seven-day consumption frequencies of individual foods within each food group by season and by region (back to text)

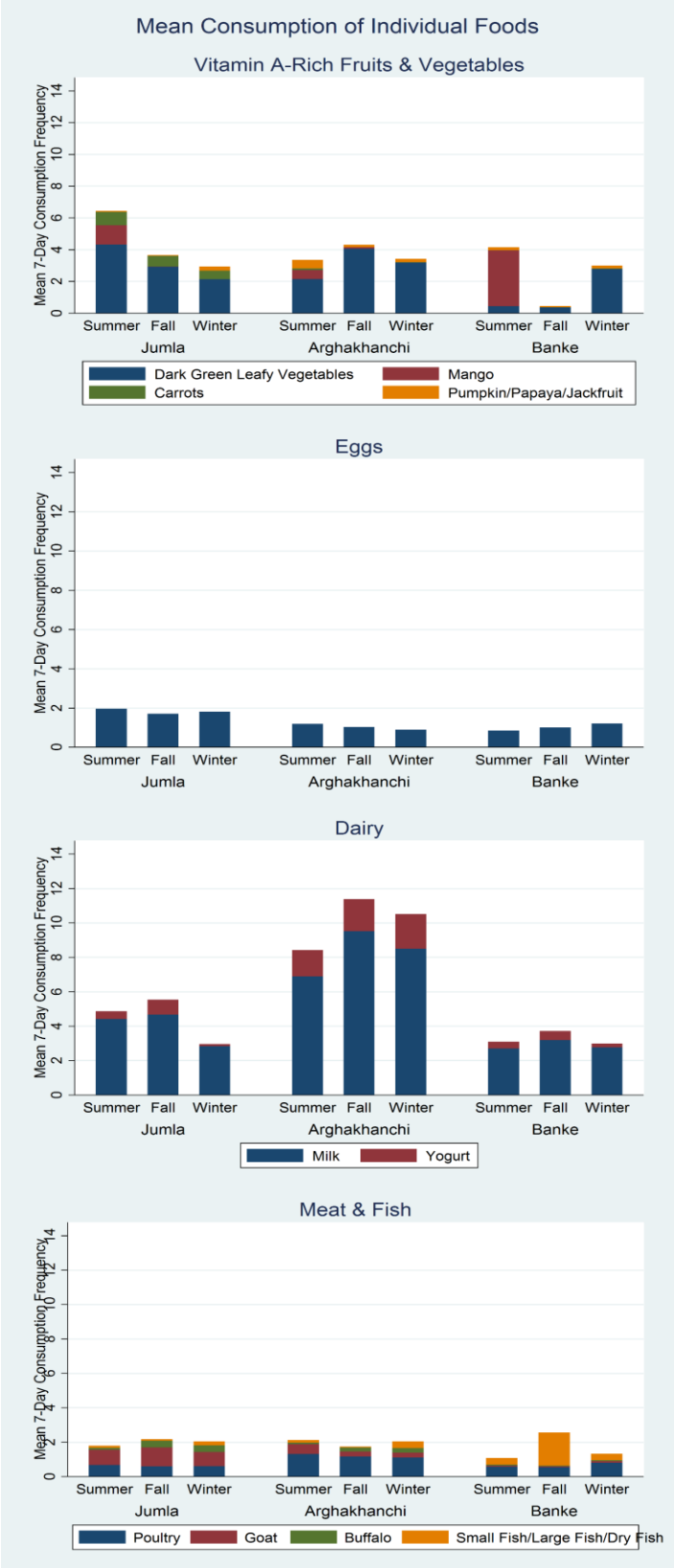


Figure 6. Percent of children's total seven-day consumption frequency of each food group contributed by individual foods, by region and by season (back to text)

Figure 7. Marginal plots showing average adjusted predictions and 95% confidence intervals for children's mean seven-day consumption frequency of each food group by season (back to text)

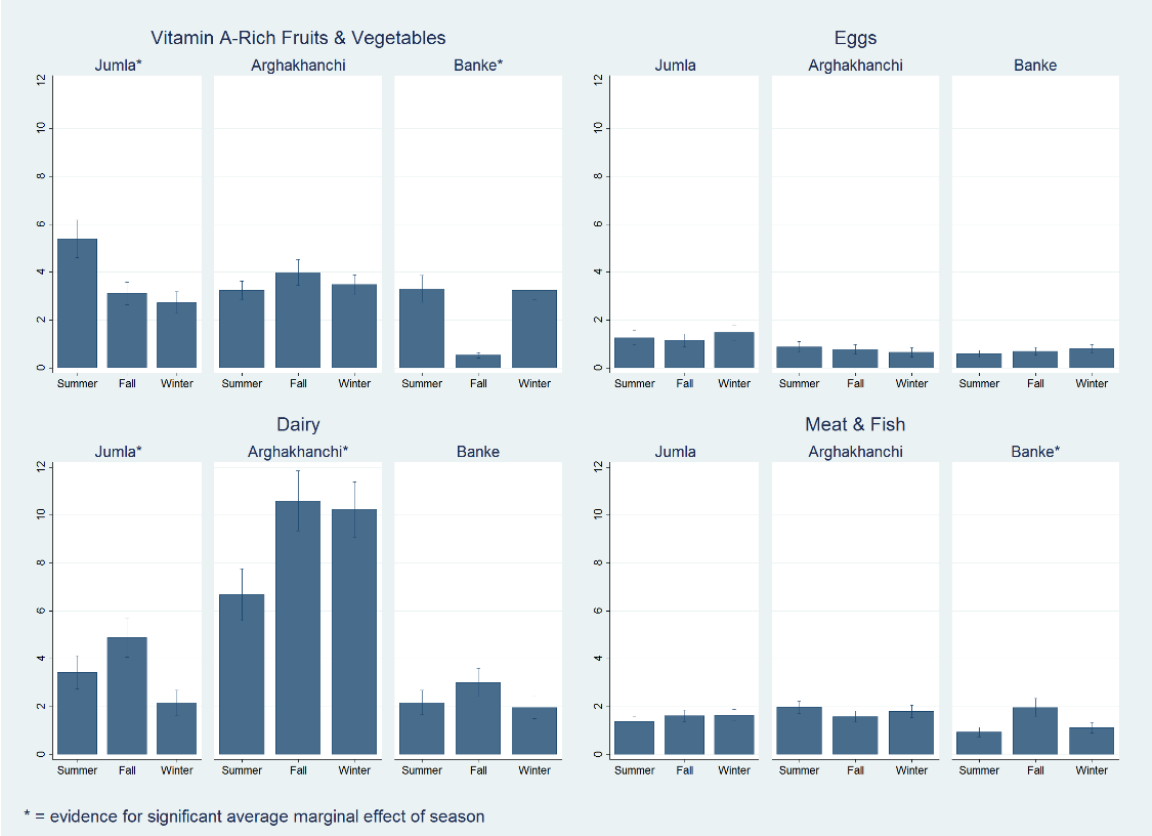


Figure 8. Marginal plot showing average adjusted predictions and 95% confidence intervals for children's seven-day vitamin A-rich fruit and vegetable consumption frequency in Jumla, disaggregated by wealth tertile (back to text)

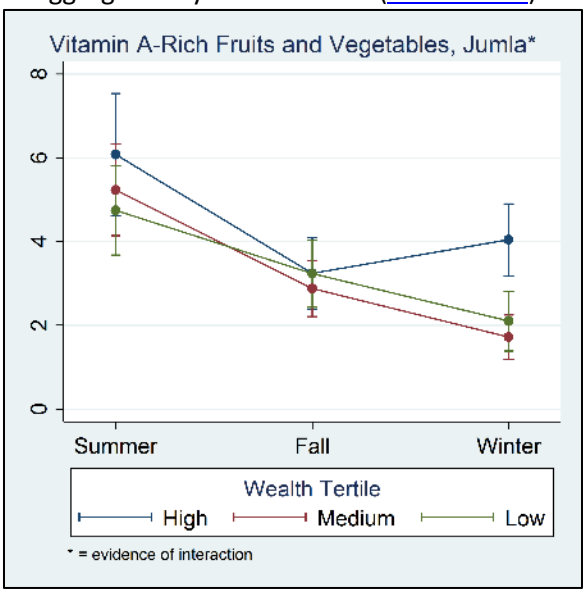


Figure 9. Marginal plot showing average adjusted predictions and 95% confidence intervals for children's seven-day egg consumption frequency in Banke, disaggregated by caste/ethnicity (back to text)

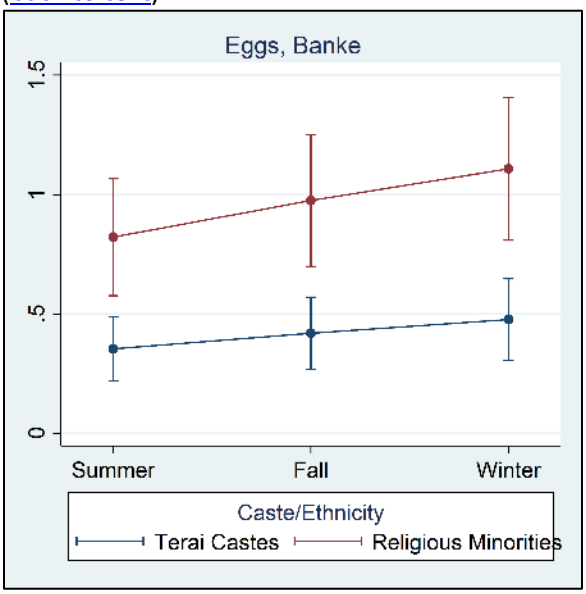


Figure 10. Marginal plots showing average adjusted predictions and 95% confidence intervals for children's seven-day dairy consumption frequency in Jumla, Arghakhanchi, and Banke, disaggregated by caste and/or wealth tertile (back to text)

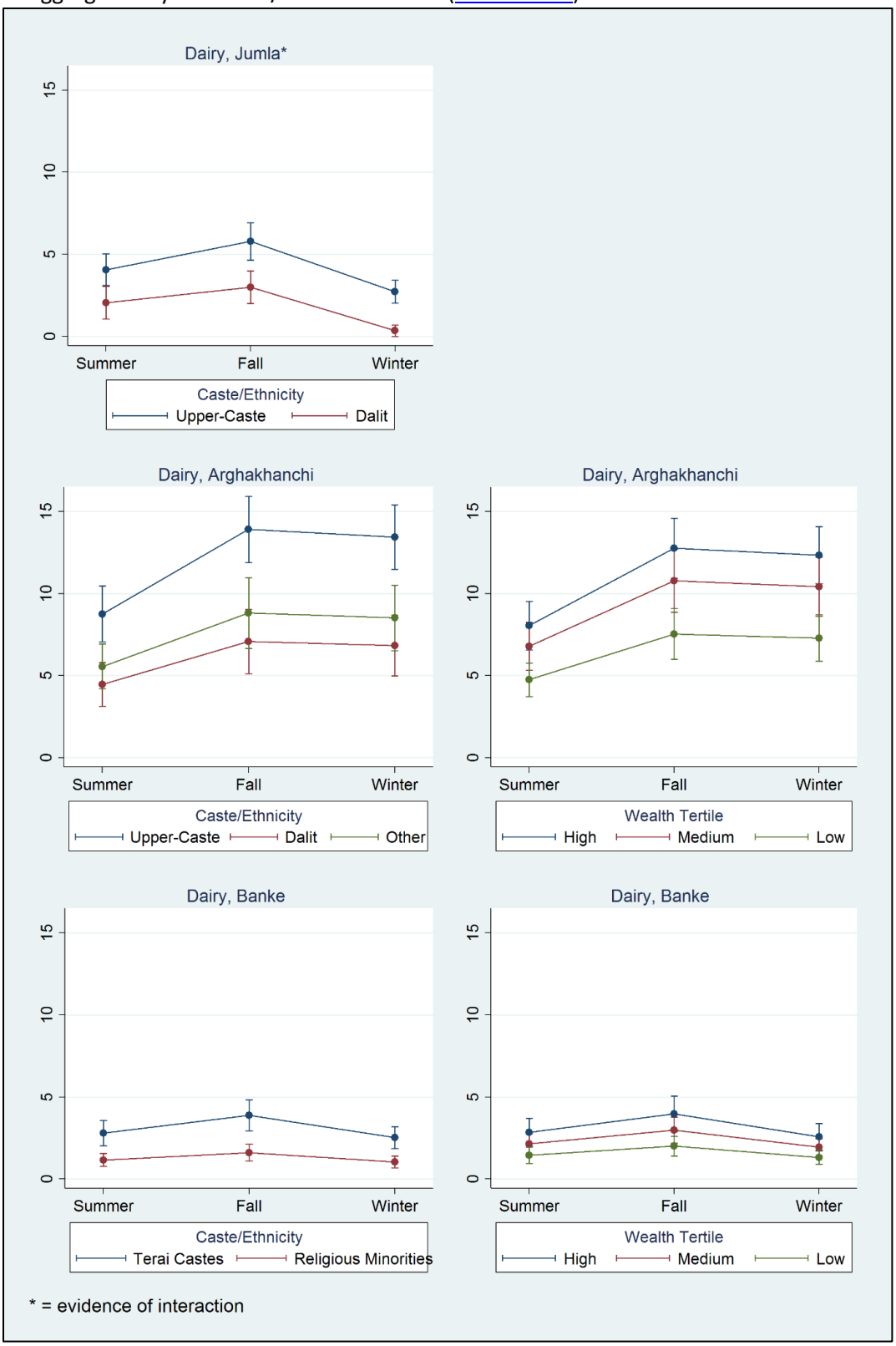
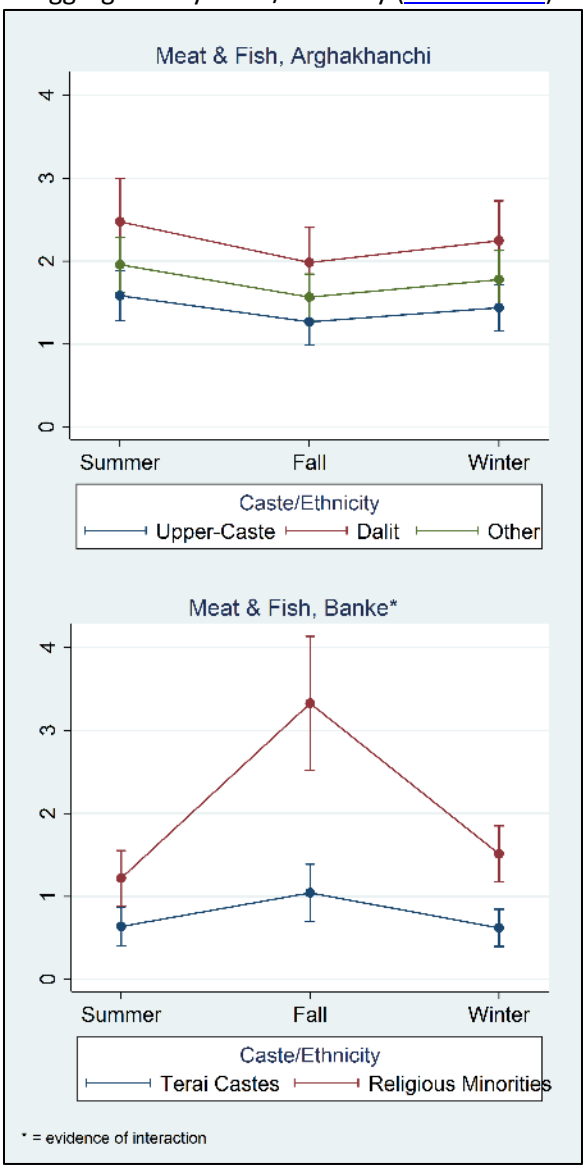


Figure 11. Marginal plots showing average adjusted predictions and 95% confidence intervals for children's seven-day meat and fish consumption frequency in Arghakhanchi and Banke, disaggregated by caste/ethnicity (back to text)



Chapter 5. Home Production and Purchasing of Non-Staple Nutritious Foods in Nepal: associations with child diet and predictors of production and purchasing

5.1 Abstract

Background: Poor quality diets contribute to high rates of undernutrition among young children in Nepal. Integrated nutrition programs often aim to improve children's diets by promoting household production and purchasing of non-staple nutritious foods, and by improving knowledge about child nutrition, usually among mothers. To identify where and for whom such programs are likely to be beneficial, we need a better understanding of the relationships between household production and purchasing of nutritious foods, mother's nutrition knowledge, and children's dietary intake, as well as the determinants of nutritious food production and purchasing. We therefore conducted a series of analyses guided by a conceptual model based on the assumed relationships that underlie integrated nutrition programs, and an integrated food and nutrition systems framework.

Methods: Using survey data collected from farming households in three geographically diverse Nepali communities at four different timepoints (N = 485; total surveys= 1,449), we ran negative binomial regressions to determine whether children's weekly consumption frequencies of four non-staple nutritious food groups (vitamin A-rich fruits and vegetables, eggs, meat, and dairy) were associated with household expenditure and production, with mother's nutrition knowledge and decision-making power, and with caste/ethnicity. We then ran logistic regressions to determine whether the likelihood of household production and expenditure for each food type was associated with region, season, access to resources, caste/ethnicity, and mother's nutrition knowledge and decision-making power.

Results: Children's predicted consumption frequencies of vitamin A-rich fruits and vegetables, eggs, meat, and dairy increased significantly with greater household production of and expenditure on each food type. Likelihood of household production and expenditure differed significantly by season and geographic region. For nearly all food types, likelihood of production increased significantly with greater land ownership, and likelihood of expenditure increased significantly as wealth increased. Production, purchasing, and children's consumption of specific foods varied substantially by caste/ethnicity. Mothers' nutrition knowledge had a small positive association with children's consumption frequency of vitamin A-rich fruits and vegetables. Otherwise, mother's nutrition knowledge and decision-making power were not significantly associated with consumption, production, or expenditure.

Conclusions: Program strategies that successfully increase household production of and/or expenditure on non-staple nutritious foods are likely to increase children's consumption frequency of non-staple nutritious foods. However, increasing household production of and expenditure on non-staple nutritious foods will require addressing resource access challenges as well as regional and seasonal variations in production capacity and market availability/price. Without changing the structural factors which constrain food access and feeding options, greater nutrition knowledge among mothers is unlikely to increase their children's consumption of nutritious foods.

5.2 Introduction

The quality of a child's diet impacts their micronutrient status, growth, and development and depends largely upon consumption of non-staple, nutrient-rich foods.[6, 9, 32] In Nepal, as in many other low-income settings, children consume a primarily cereal-based diet very low in non-staple nutritious foods and with overall insufficient energy intake.[31] [8, 32] Key food groups

which are infrequently consumed, yet nutritionally important, include vitamin A-rich fruits and vegetables and animal source foods. [33] [34, 36]

To improve child nutritional status, integrated agriculture-nutrition interventions are increasingly being implemented across Nepal and in many other low-income countries.[7, 9, 17] Such interventions take a wide variety of forms, reflecting the complex combination of factors that drive undernutrition. Many include components that aim to improve household access to non-staple nutritious foods by promoting both their production and purchase, and to improve knowledge, particularly among mothers, regarding the importance of including such foods in the diets of young children.[14-17]

The complexity of integrated nutrition programs makes it difficult to determine how to effectively design and implement them.[14, 19, 93, 94] Increasingly, experts in the agriculture-nutrition field advocate that researchers focus on enhancing understanding of specific program components and specific effect pathways in order to effectively inform integrated nutrition program strategies,[18, 19] and on the contextual factors that influence program implementation and effectiveness.[17, 95] Moreover, experts advocate for applying a systems perspective when assessing and selecting strategies to improve household food access and child nutrition.[7, 9] Taking a systems perspective situates program strategies within the broader context of factors affecting food production and food access. One example is the integrated food and nutrition systems framework developed initially by Sobal et. al., and adapted by Burchi, Fanzo, and Frison.[9, 20] This framework depicts production and consumption sub-systems and how they are impacted by contextual factors via access to resources. It emphasizes the importance of factors in the biophysical environment, such as climate, geography, and land; and factors in the

sociocultural environment, such as cultural and religious values and practices, social norms, and social status.

Drawing upon the integrated food and nutrition systems framework and the assumed relationships that underlie integrated nutrition programs, we developed the conceptual model shown in Figure 12. This conceptual model illustrates the hypothesized relationships between household production and purchasing, mother's nutrition knowledge, and child diet quality, as well as the biophysical, sociocultural, and resource access factors expected to influence production and purchasing within the context of Nepal. Through this analysis, we aimed to determine whether the relationships reflected in this conceptual model are, in fact, supported by data from Nepali farming households. Grey boxes and arrows indicate conceptual model components that we were not able to examine in this analysis.

Previous studies have documented associations between children's diet quality or nutritional status and household production of nutritious foods,[7, 16, 59, 96] household expenditure on nutritious foods,[29, 97] mother's nutrition knowledge and decision-making power,[98, 99] and caste/ethnicity.[31, 34, 100] However, few have examined these predictors simultaneously so that the relative strengths of their adjusted associations can be assessed, or examined their effect on frequency of children's consumption of specific food types, rather than dichotomous outcomes or composite indicators like dietary diversity. Additionally, few studies have specifically examined the influence of contextual factors on household food production and expenditure practices.[17]

Three research questions guided this analysis:

1. Are household production, household purchasing, mother's nutrition knowledge, and caste/ethnicity associated with children's weekly consumption frequency of non-staple nutritious foods?

2. Are region, season, land ownership, water access, wealth, caste/ethnicity, and mother's nutrition knowledge associated with likelihood of household production of non-staple nutritious foods?

3. Are region, season, wealth, caste/ethnicity, and mother's nutrition knowledge associated with likelihood of household purchasing of non-staple nutritious foods?

All three of these research questions are important, but for slightly different reasons. Question one, about consumption frequency, assesses whether our empirical data support the existence and importance of the pathways through which many nutrition programs are expected to achieve outcomes. Questions two and three, regarding production and purchasing, have implications for broader questions regarding equity and potential levers of change. For example: Which types of households will likely be able to increase household access to nutritious foods via production and purchasing? What types of assistance may other households need?

5.3 Methods

5.3.1 Data description

Data for this analysis were collected in three rural Nepali communities as part of the larger Policy and Science of Health, Agriculture, and Nutrition (PoSHAN) data collection system. The PoSHAN study received approval from the institutional review board at the Johns Hopkins Bloomberg School of Public Health, and from the Nepal Health Research Council. The three

study communities lie in the mountain district of Jumla, the mid-hills district of Arghakhanchi, and the low-lying plains region of Banke. Within each community, three wards (the smallest governmental administrative unit in Nepal) were randomly selected and within those wards all households that contained a child under the age of six[1], or a pregnant or newly married woman were invited to participate in the PoSHAN study. Households were surveyed seasonally (three times a year) between May 2013 and February 2015, and once a year between May and June thereafter. Klemm et al. provide a detailed description of the PoSHAN study design.[71] Data collected included household agricultural production during the preceding growing seasons, agricultural practices and livestock ownership, household economic and expenditure information, women and children's dietary intake, and questions addressing women's participation in household decision-making and knowledge regarding child care and feeding practices.

This analysis used data from four timepoints during the two years when households were surveyed seasonally: the 2013 and 2014 summer/monsoon (May-July) seasons and the 2014 and 2015 winter (January-February) seasons. Additionally, data regarding agricultural production for each timepoint were drawn from the survey round that occurred several months later. Because the agricultural portion of the survey asked respondents to report their total production for the previous season, we drew data from different timepoints to ensure that agricultural production data corresponded to the same season for which dietary intake and expenditure data were reported.

As shown in Figure 13, the PoSHAN study population within Jumla, Arghakhanchi, and Banke included a total of 706 households and the study conducted a total of 2,202 surveys of

[1] The age cut-off was five during the first year of data collection and six thereafter.

those households (referred to as observations) during the four timepoints mentioned above. Criteria for inclusion in this analysis included being a farming household (defined as a household that reported growing at least one field crop in the previous year), having a child between 6 and 72 months in the household, and having the index child's primary caretaker be their mother (or in some cases another female relative). One child was randomly selected as the index child in cases where the household contained two or more 6-72-month-old children, and the mother of that child was designated as the index mother. Removal of households not meeting the above criteria yielded a total analysis sample of 485 household and 1,449 observations.

5.3.2 Variables

As shown in Table 5, we examined four different outcome variables for each of the three research questions that this analysis aimed to answer. For the research question about consumption frequency, outcome variables were children's weekly consumption frequency of vitamin A-rich fruits and vegetables, eggs, meat, and dairy. We generated these variables by summing the number of times that a child consumed foods falling into each of those food groups, based on a seven-day food frequency questionnaire administered to each child's mother.

Outcome variables for the research question about production were household fruit and vegetable production, ownership of poultry, ownership of meat animals, and ownership of cattle. Meat animals included animals commonly raised specifically for consumption in Nepal (i.e. not buffalo, which may be eaten, but primarily are kept for milk production and as work animals): poultry, goats, guinea fowl/pigeons, pigs, and rabbits. These variables were generated from a survey module on agricultural production that asked households to list all fruits and vegetables they produced, and how much of each they produced during the past growing

season, as well as which types of livestock and how many of each they currently owned. As mentioned above, data on fruit and vegetable production for each timepoint were drawn from the following survey round, so that it reflected production during that timepoint's growing season. Given the non-normal distributions for amount of fruit and vegetable production and numbers of livestock owned, we created dichotomous variables using any production/ownership vs. none as a cut-point.

For the research question about purchasing, we examined 30-day household expenditure on vitamin A-rich fruits and vegetables, eggs, meat, and dairy. The PoSHAN study collected these data using an expenditure survey that listed all of the foods included on the food frequency questionnaire. To generate outcome variables for this analysis, we summed all expenditure on foods within each food group. Due to non-normality of distributions we again dichotomized each variable, this time using the 25% percentile of those with any expenditure as a cut-point so that categories were none or low vs. medium or high expenditure.

Table 5 also displays the predictor variables corresponding to each research question. For the research question about consumption frequency, the same variables examined as outcomes for research questions regarding production and purchasing were included as predictors, but were categorized differently. All expenditure variables, as well as fruit and vegetable production and livestock ownership variables, were categorized as none, low, medium, or high, using the 25^{th} percentile and 75^{th} percentile values of those with any expenditure or production/livestock ownership as the cut-points between low and medium, and medium and high, respectively. We also adjusted for potential gender and age-related differences in children's consumption frequencies by including these two variables in regressions for research question one.

Regressions for research questions about production and purchasing contained season and region as predictor variables, as well as interaction terms to allow for differing effects of season by region. Season and region were not included in regressions for the research question about consumption frequency. This is because, as shown in our conceptual model, we expected any potential influence of season and region on consumption to occur *via* production or purchasing. Additionally, based on our conceptual understanding, we had no reason to expect season or region to moderate the relationship between production or expenditure and consumption.

Season reflected whether data were collected during the summer/ monsoon season, (timepoints 1 and 3), or during the winter (timepoints 2 and 4). Region reflected the agroecological region of each community (mountains, hills, or plains), however with only one community per region, this variable's coefficients are more accurately interpreted as community differences that may or may not be generalizable to the region more broadly. Regressions for the research question about production also included variables for land ownership, distance to water source, and wealth. Regressions for the research question regarding purchasing included just the variable for wealth. The land ownership variable was generated by assigning households to low, medium, or high tertiles based on the amount of land that they reported owning. Distance to water was based on the number of minutes required to walk to the household water source, and was categorized as none (meaning water was available within the household compound), five minutes or less, five to ten minutes, or more than ten minutes. The wealth variable was created using principle components analysis to generate an index score based on survey items regarding household construction materials and asset ownership. Households were then assigned to low, medium, or high wealth tertiles based on their index score. In the

regressions for the research question about purchasing, we also adjusted for whether households were producers of the food or not.

Caste/ethnicity, mother's child nutrition knowledge, and mother's decision-making power were included as determinants in regressions for all three research questions. Caste/ethnicity was defined using the categories specified within Nepal's Health Management Information System, which are: Dalit, Disadvantaged Janajati, Disadvantaged Terai Castes, Religious Minorities, Advantaged Janajatis, and Upper Caste.[86] We used two index scores as indicators for mother's child nutrition knowledge and decision-making power: the mother's complementary feeding knowledge (CFK) index, and the mother's household decision-making participation (HDMP) index. We generated the CFK index by summing the number of non-staple nutritious foods that mothers mentioned when asked which foods should be fed to 6-11-month-old children. Scored answers included dark green leafy vegetables, yellow fruits and vegetables, eggs, and meat/fish. Although the score is intended to measure complementary feeding knowledge, it reflects mother's knowledge regarding the importance of non-staple nutritious foods for young children, and therefore was selected as a proxy for mother's nutrition knowledge. We generated the HDMP index using a survey module that asked mothers whether they were a primary or joint decision-maker for a series of 14 possible household decisions. Examples include decision-making about daily household expenditure, feeding children, taking crops to market, non-farm business activity, and traveling to visit family. We scored the index by summing the number of household decisions that mothers reported participating in, dividing it by the total number of household decisions made (as some decisions were not applicable for all households), and multiplying it by ten. The score can therefore be interpreted as the number of household decisions out of ten that a mother participates in.

Missing values were negligible for most variables, with only two observations including missing values for consumption variables (one each for meat and dairy), three observations missing values for poultry ownership, and four observations missing values for meat animal ownership. These missing values were handled using case-wise deletion. No expenditure variable or predictor variable values were missing. However, 87 observations were missing values for fruit and vegetable production, representing 6% of all observations. As mentioned above, fruit and vegetable production data came from the survey round following each time period included in this analysis. Therefore, these missing values are attributable to households that were surveyed during the time period included in analysis, but not during the following survey round, primarily due to households no longer meeting study criteria because children reached the study's age cut-off for inclusion. See Appendix 2 for further information on the reasons for incomplete data panels. Observations with missing fruit and vegetable production data were removed from regressions including that variable, but included in all other regressions.

5.3.3 Statistical analysis

After calculating descriptive statistics for the analysis sample and outcome variables, we used generalized-estimating equation (GEE) models to generate population-averaged estimates of the associations between variables of interest, while accounting for the correlation among repeated measures on the same household. All analyses were conducted in Stata 14.[87] We selected negative binomial GEE models for regressions corresponding to consumption frequency outcomes, in order to accommodate the over-dispersion of the consumption frequency data. [89, 101] These models yielded estimates in the form of incident rate ratios (IRR), as described in Table 5. We selected logistic GEE models to accommodate the dichotomous outcomes for research questions regarding production and purchasing.

We first fit bivariate models to assess the unadjusted relationship between each predictor variable and outcome while accounting for correlation between repeated measures. We then fit initial multivariate models for each of the four outcomes corresponding to each research question, including all relevant predictor variables of interest (see Table 1), as well as terms for the interaction of mother's nutrition knowledge and decision-making power (for all outcomes), and of season and region (for production/livestock ownership and expenditure outcomes). Finally, to ease interpretation, final model estimates were used to plot predicted marginal values of each outcome at each predictor variable level.

5.4 Results

In the results section below, we first describe summary statistics for each of the outcome variables. In the subsequent three sub-sections, we present results for the three analyses conducted: predictors of children's consumption frequency for each of the four food types; predictors of household production of each of the four food types; and predictors of household expenditure on each food type.

5.4.1 Sample characteristics and outcome summary statistics

Table 6 provides characteristics of households included in the analysis sample at each of the four data collection time points. Table 7 provides descriptive statistics for the consumption frequency outcome. Children's consumption of non-staple nutritious foods was very low over all, with most not consuming any eggs or dairy within the seven days prior to the survey, and median consumption of vitamin A-rich fruits and vegetables and meat at twice per week and once per week, respectively. As the descriptive statistics show, distributions were also heavily right-skewed, with most children consuming very few of each food type, but a few consuming each food multiple times per day.

Regarding fruit and vegetable production and livestock ownership, as shown in Table 8, the majority of households owned cattle (71%) and meat animals (67%), about half of households produced any fruits and vegetables (52%), and a little over a third of households owned poultry (36%). As shown in Table 9, expenditure on meat was highest compared to the other food groups, with 83% of households purchasing meat in the 30 days prior to the survey and spending a median amount of 1000 NPR (equivalent to about 10 US dollars). Far fewer households purchased vitamin A-rich fruits and vegetables, eggs, or milk (36%, 35%, and 30%, respectively). Among those households that did, expenditure was highest on milk with a median of 400 NPR. Median expenditure on vitamin A-rich fruits and vegetables and eggs was 200 NPR and 180 NPR respectively.

Figures 14 and 15 show the percent of households that produced foods, purchased foods, both produced and purchased foods, and neither produced nor purchased foods. Figure 14 disaggregates this data by region and Figure 15 disaggregates it by season. These summary statistics indicate that household access practices (i.e. production and/or purchasing) vary substantially across regions and across food types. Variations in access practices by season are much smaller, with the exception of vitamin A-rich fruits and vegetables. The percent of households purchasing vitamin A-rich fruits and vegetables decreased dramatically in the winter compared to the summer. Interestingly, percent of households producing vitamin A-rich fruits and vegetables increased in the winter compared to the summer.

5.4.2 Variables associated with children's consumption frequency of non-staple nutritious foods

Greater expenditure was significantly associated with higher consumption frequencies of all foods, and greater production was associated with higher consumption frequencies of vitamin A-rich fruits and vegetables, eggs, and dairy. For meat, only a high level of livestock

ownership was associated with increased consumption. Figure 16 shows the relationships between production, expenditure, and consumption for each food type. Tables 10, 11, 12, and 13 present the bivariate and multivariate coefficient estimates for the models for consumption of vitamin A-rich fruits and vegetables, eggs, meat, and dairy, respectively. Ownership of cattle was associated with the largest increases in consumption frequency, with low ownership (1 animal) estimated to double children's weekly consumption frequency of dairy, and high ownership (5 or more cattle) estimated to more than triple consumption frequency ($p < 0.001$). Meat animal ownership was associated with the smallest increases, with ownership of eight or more animals estimated to increase meat consumption by about 40% ($p < 0.001$). Low, medium, and high fruit and vegetable production was estimated to increase consumption of vitamin A-rich fruits and vegetable by 50%, 70%, and 90%, respectively ($p < 0.001$). Interestingly, low poultry ownership (1-2 birds) was estimated to increase egg consumption nearly three-fold ($p < 0.001$), while the coefficient estimates for medium and high poultry ownership were somewhat lower, although the confidence intervals for these estimates overlapped.

Estimates for expenditure level coefficients also demonstrated significant associations with children's consumption frequencies. Medium and high levels of expenditure were associated with increased consumption for all food types, and low expenditure was significantly associated with increased consumption of eggs and meat but not vitamin A-rich fruits and vegetables or dairy. High expenditure levels were associated with a substantial and highly significant consumption increase for all food types—an over seven-fold increase for egg consumption, over five-fold increase for meat consumption, and an over two-fold increase for both vitamin A-rich fruits and vegetables and dairy ($p < 0.001$). Increases associated with medium expenditure ranged from a four-fold increase for eggs ($p < 0.001$) to a 40% increase for

dairy ($p < 0.01$). Low expenditure was associated with a 140% increase for both eggs and meat ($p < 0.001$).

There were also significant differences in children's consumption frequency by caste and ethnicity, although the magnitude of the estimated differences was generally smaller than those associated with production/livestock ownership and expenditure. The most notable differences were seen in relation to meat and dairy consumption frequency. Disadvantaged Terai caste, religious minority, and upper caste children were all estimated to have significantly lower meat consumption frequency compared to Dalit children (60% less, 40% less, and 30% less, respectively; $p < 0.001$). Regarding dairy, children from both disadvantaged and advantaged Janajati and upper caste households were estimated to have significantly higher weekly dairy consumption than Dalit children (140% higher, 80% higher, and 110% higher, respectively; $p < 0.001$), while religious minorities were estimated to have 50% lower dairy consumption ($p < 0.01$).

Mother's complementary feeding knowledge score was significantly associated with a slight increase in children's consumption frequency of vitamin A-rich fruits and vegetables of about 10% ($p < 0.001$) and but was not associated with consumption of the other three food groups. Neither mother's household decision-making participation score, nor the interaction between mother's nutrition knowledge and decision-making score showed any significant associations with children's consumption frequency of any of the four food groups.

5.4.3 Variables associated with household production of fruits and vegetables and livestock ownership

Household fruit and vegetable production and each type of livestock ownership varied substantially by region, and both fruit and vegetable production and cattle ownership also

varied by season, with seasonal effects differing by region. As Figure 17 shows, households in the hills were substantially more likely to be producers/livestock owners than households in the mountains or Terai/plains, and households in the Terai/plains were more likely to own meat animals than households in the mountains, regardless of season. In the summer, households in the hills were more likely to produce fruits and vegetables than households in the Terai/plains, while in the winter the situation reversed. Cattle ownership did not differ significantly by season in the hills or Terai/plains, however in the mountains it was substantially higher in the winter compared to the summer.

Coefficient estimates for each of the production/livestock ownership outcomes are shown in Table 14. Greater land ownership was associated with a greater likelihood of producing fruit and vegetables, owning meat animals, and owning cattle, with high land ownership associated with a nearly two-fold increase in the odds of fruit and vegetable production and meat animal ownership ($p < 0.01$), and an over three-fold increase in the odds of cattle ownership ($p < 0001$). Multivariate analysis indicated that households that had to travel more than 10 minutes to reach their water source had 40% lower odds of producing fruits and vegetable ($p < 0.05$), and indicated no association between distance to water source and livestock ownership.

The odds of upper caste households producing fruits and vegetables were twice those of Dalit households ($p < 0.001$), while religious minority households had 50% lower odds ($p < 0.001$). The odds of religious minorities and disadvantaged Janajatis owning poultry were well over three times those of Dalit households ($p < 0.01$) and odds of disadvantaged Janajatis owning meat animals were also well over four times those of Dalit households ($p < 0.001$). Odds of poultry ownership were very low among disadvantaged Terai castes—90% lower than those

of Dalit households ($p < 0.001$). Mother's complementary feeding knowledge score was not significantly associated with any outcomes, however mother's household decision-making participation score had a small, but highly significant, negative association with odds of cattle ownership (IIR: 0.9, $p < 0.001$). Interactions between mother's complementary feeding knowledge household decision-making scores also showed no significant associations.

5.4.4 Predictors of household expenditure on non-staple nutritious foods

Household expenditure also varied substantially by region, and in some cases by season (Figure 18). Likelihood of expenditure on vitamin A-rich fruits and vegetables and eggs was lowest in Arghakhanchi, and likelihood of expenditure on meat was lowest in Banke. Expenditure on dairy was substantially higher in Banke compared to the other two regions. Findings indicated a small increase in Banke in likelihood of expenditure on eggs in the winter compared to the summer, and a significant decrease in likelihood of expenditure on vitamin A-rich fruits and vegetables during the winter across all three locations.

Likelihood of expenditure increased significantly with greater household wealth across all food groups, with between a three and four-fold increase in odds of consumption ($p < 0.001$). Coefficient estimates for all expenditure outcomes are shown in Table 15. There was also some difference in expenditure by caste/ethnicity, with 80% and 60% greater odds of upper-caste households having medium or high expenditure on vitamin A-rich fruits and vegetables and dairy, respectively ($p < 0.05$), compared to Dalit households, and 60% lower odds of disadvantaged Terai castes having medium or high expenditure on meat compared to Dalit households. Finally, although bivariate estimates indicated a small positive association between mother's complementary feeding knowledge index score and expenditure on vitamin A-rich fruits and vegetables, this relationship did not prove to be significant in the multivariate

regression. Similarly, there was no significant relationship between mother's household decision-making participation score and any expenditure outcome variable, or between expenditure outcomes and the interaction between complementary feeding knowledge score and household decision-making participation score.

5.5 Discussion

Analysis results, summarized in Table 16, clearly indicate the relationship between a household's access to non-staple nutritious foods, whether via their own production or purchasing, and children's consumption frequency of those foods. So, which factors influence whether a household will produce or purchase a given food? For this we turn to the findings from research questions two and three, which indicate the importance of geography, season, land ownership (for production), and wealth (for expenditure). Children's consumption frequencies, household likelihood of production, and household likelihood of expenditure for nearly all non-staple food types also differed significantly by caste and ethnicity. Our findings concur with other studies that indicate the importance of season,[13, 32, 47] geography,[13, 62] access to resources like land and wealth,[100, 102] and caste/ethnicity[31, 100] in determining child nutrition and household food access. This analysis builds upon such studies by demonstrating how these factors likely impact child diet quality via their effects on household production of and expenditure on vitamin A-rich fruits and vegetables and animal source food.

Other than a small increase in predicted consumption of vitamin A-rich fruits and vegetables as mother's complementary feeding knowledge scores increased, findings provided no evidence that the children of mothers with greater nutrition knowledge consumed more non-staple nutritious foods. Findings also provided no evidence that households where mothers had better nutrition knowledge were more likely to produce or purchase non-staple nutritious

foods, or that mothers with greater decision-making power in combination with greater nutrition knowledge increased their children's nutritious food consumption frequency, or household production and purchasing practices. These findings should not be interpreted to mean that nutrition knowledge and women's ability to participate in household decision-making are not important. Previous studies have documented the relationship between knowledge and decision making and child nutrition.[97-99, 103] There are myriad pathways through which a mother's nutrition knowledge likely impacts her child's dietary intake that are not captured in this analysis. For example, knowledge may impact amounts consumed, preparation methods, and attentiveness during feeding, rather than consumption frequency. Additionally, we should note that both knowledge and decision-making are complex, difficult-to-measure constructs, and our lack of significant findings may be due to inadequacies of our indicators.

However, the fact that findings *did* indicate a positive association between mother's nutrition knowledge and vitamin A-rich fruit and vegetable consumption suggests that the lack of association with other food types may be due to the limited ability of mother's nutrition knowledge to impact children's consumption of foods that are difficult to access. Vitamin A-rich fruits and vegetables are relatively more accessible than animal sources foods, as they are less expensive to purchase and can also be foraged. Mothers with greater nutrition knowledge therefore may have the access needed to act on their knowledge regarding feeding of vitamin A-rich fruits and vegetables, whereas the difficulty of accessing animal source foods may mean mothers are constrained in increasing their children's consumption frequency of eggs, meat, and dairy, regardless of their knowledge.

Broadly, our findings suggest that household access factors (production and expenditure) are the crucial determinants of children's consumption frequency of non-staple nutritious foods,

and that environmental and resource access factors are the crucial determinants of household access via production and expenditure. They also suggest the important influence of social group (i.e. caste/ethnicity), likely via group-specific food and food-production preferences and proscriptions,[83, 84] as well as due to effects of caste/ethnicity on resource access (unmeasured in this analysis).[82, 100] Finally, they indicate that mother's nutrition knowledge, even when considered in conjunction with her decision-making power, is not a primary driver of the outcomes examined. As noted above, this does not mean that a mother's nutrition knowledge and decision-making power are not important for child nutrition, but it suggests that factors beyond the individual or even household level constrain a mother's ability to make changes in her child's diet based on her knowledge. These findings make sense when situated within the sociological debate regarding the relative roles of agency and structure in determining behavior.[21-23] According to theorists like Cockerham, Frohlich, and Delormier who have applied these concepts in the areas of health and nutrition, individual-level factors such as a mother's nutrition knowledge and decision-making power correspond to agency.[24, 25] As Cockerham explains, "while agency is important… structural conditions can act back on individuals and configure their lifestyle patterns in particular ways. Agency allows them to reject or modify these patterns, but structure limits the options that are available." In this case, environmental factors, sociocultural factors, and resource access comprise the structures that households and individuals are nested within. From this theoretical perspective, our finding that structural factors, rather than individual-level factors, are the most significant predictors of production of, expenditure on, and children's consumption of non-staple nutritious foods is unsurprising.

Our findings also shed light on those from two recent nutrition-sensitive agriculture program evaluations carried out in Nepal. In their study of the multi-sectoral integrated nutrition program Suaahara, Cunningham et al. found that nutrition-related knowledge and

likelihood of practicing promoted nutrition-related behaviors (including feeding children key non-staple nutritious foods) was significantly higher among intervention-area households than those in comparison areas, and that disparities in knowledge and reported practices between disadvantaged and non-disadvantaged households were smaller in intervention-area households.[12] However, the differences in knowledge, and reduction in disparities related to knowledge, were greater than the differences and reduction in disparities related to reported nutrition-related practices. As the authors noted, this may be due to income-, social norm-, self-efficacy-, and food access-related constraints to the translation of knowledge into behaviors. Indeed, our findings suggest that structural constraints on a households' ability to produce and/or purchase nutritious foods are likely responsible—factors that also may impede households' abilities to participate in and practice the behaviors promoted by the program's agricultural components.

Secondly, an impact evaluation of a Heifer International intervention by Darrouzet-Nardi et al. that promoted livestock husbandry indicated that the program increased children's diet quality in the hills, but not in the plains.[13] The authors note that the lack of impact in the plains may be due to the comparatively better child diet quality there prior to the intervention which left less "room for improvement," or to the hills being a more suitable environment for livestock husbandry compared to the plains. Viewed in light of our findings, the answer is likely largely the latter. It would also be worth examining whether program impact differed depending on land ownership, as our results suggest this also effects a household's ability to raise livestock, and consequently may determine the extent to which they can benefit from a program promoting livestock husbandry.

Taken together, our findings and those of the two evaluations described above indicate: 1) the potential to improve child diet quality in Nepal via interventions that promote household production of non-staple nutritious foods; 2) the need to address structural factors that constrain behavior in order to achieve full potential impact; 3) the need to consider contextual factors that determine a household's ability to benefit from a program, and to target and tailor program strategies accordingly.

5.6 Limitations and Future Research

As noted above, a key limitation of this analysis was the use of a simple measure of complementary feeding knowledge as a proxy for mother's nutrition knowledge. Developing a validated scale would have been ideal. However, given that we were limited to items included on the pre-existing survey, we selected the best measure available to us. Other limitations were the lack of data on the amounts of each food item consumed, in addition to consumption frequency, and lack of data on amounts of non-staple nutritious food obtained by households via hunting, gathering, and fishing. In the Terai/plains region particularly, fishing is an important source of food that was not captured in this analysis.

Future research should explore the relationships noted in the conceptual model that were not explored in this analysis. For example, more knowledge is needed regarding how environmental factors and sociocultural factors effect resource access, and about the relationships between season, geography, market factors, and household expenditure. Such information will further inform program strategies for improving child diet quality in Nepal by indicating the mechanisms through which these factors impact household food access, and potential strategies for addressing them.

5.7 Conclusion

Our results support the assumption underlying most integrated nutrition programs that increasing household access to nutritious foods will improve children's diet quality. With the exception of meat, for which household expenditure appears to be the main determinant, both increasing household production of non-staple nutritious foods via garden cultivation and livestock ownership, and increasing household expenditure on non-staple nutritious foods are likely to be effective strategies for increasing children's consumption of these foods. However, structural factors may constrain the potential for households to increase their production and expenditure. Improving child diet quality on a large-scale in Nepal will therefore require addressing resource access challenges, such as disparities in land ownership and wealth, and addressing regional and region-specific seasonal variations in household capacity to produce and purchase non-staple nutritious foods.

5.8 Tables for Chapter 6

Table 5. Description of analysis method, outcomes examined, predictor variables, and model estimate interpretation for each of the three research questions (RQ) addressed in this analysis (back to text)

	Analysis Method & Outcomes Examined	**Predictor Variables**	**Model Estimate Interpretation**
RQ 1: Consumption Frequency	Negative binomial regressions: **1.** Children's weekly consumption frequency of vitamin A-rich fruits and vegetables **2.** Children's weekly consumption frequency of eggs **3.** Children's weekly consumption frequency of meat **4.** Children's weekly consumption frequency of dairy	Production: • Amount of fruit and vegetables produced or number of poultry, meat animals, or cattle owned by household (corresponding to outcomes 1-4 respectively; categorized as none, low, medium, or high) Purchasing: • Household expenditure on fruits and vegetables, eggs, meat, or dairy (corresponding to outcomes 1-4 respectively; categorized as none, low, medium, or high) Sociocultural Environment: • Caste/ethnicity Individual-Level Factors: • Mother's child nutrition knowledge (using complementary feeding knowledge index score as proxy) • Mother's decision-making power (using household decision-making participation index score as proxy)	Incident Rate Ratio (IRR): The ratio of times per week that a child from a household with a given predictor variable value consumed the food group to the times per week that a child from a household with the baseline predictor variable value consumed the food group
RQ 2: Production	**Logistic regressions:** **1.** Fruit and vegetable production **2.** Household ownership of poultry **3.** Household ownership of meat animals **4.** Household ownership of cattle	**Biophysical Environment:** • Season (summer/monsoon vs. winter) • Region (mountains, hills, or plains) **Resource Access:** • Wealth (low, medium, high) • Land ownership (low, medium, high) • Distance to water source (within household, less than 5 minutes, 5-10 minutes, more than 10 minutes) **Sociocultural Environment:** • Caste/ethnicity **Individual-Level Factors:** • Mother's child nutrition knowledge • Mother's decision-making power	Odds Ratio (OR): Ratio of the odds that a household with a given predictor variable value produced fruit and vegetables/owned livestock (vs. no production/ownership) to the odds that a household with the baseline predictor variable value produced fruit and vegetables/owned livestock.
RQ 3: Purchasing	**Logistic regressions:** **1.** Household expenditure on vitamin A-rich fruits and vegetables **2.** Household expenditure on eggs **3.** Household expenditure on meat **4.** Household expenditure on dairy	**Biophysical Environment:** • Season (summer/monsoon vs. winter) • Region (mountains, hills, or plains) **Resource Access:** • Wealth (low, medium, high) **Sociocultural Environment:** • Caste/ethnicity **Individual-Level Factors:** • Mother's child nutrition knowledge • Mother's decision-making power	Odds Ratio (OR): Ratio of the odds that a household with a given predictor variable value spent a medium or high amount on the food group (vs. no or low expenditure) to the odds that a household with the baseline value spent a medium or high amount on the food group.

Table 6. Characteristics by timepoint of the analysis sample's 485 Nepali farming households located in the districts of Jumla, Argakhanchi, and Banke, that were surveyed at up to four different time points (back to text)

	Timepoint 1	Timepoint 2	Timepoint 3	Timepoint 4
Total Households (N)	350	304	417	378
Region (N (%))				
Mountains	96 (27.4%)	80 (26.3%)	111 (26.6%)	87 (23.0%)
Hills	125 (35.7%)	101 (33.2%)	136 (32.6%)	124 (32.8%)
Terai	129 (36.9%)	123 (40.5%)	170 (40.8%)	167 (44.2%)
Wealth Tertile (N (%))				
Low	117 (33.4%)	102 (33.6%)	140 (33.6%)	132 (34.9%)
Medium	118 (33.7%)	102 (33.6%)	139 (33.3%)	120 (31.7%)
High	115 (32.9%)	100 (32.9%)	138 (33.1%)	126 (33.3%)
Land Ownership Tertile (N (%))				
Low	98 (28.1%)	83 (27.3%)	138 (33.2%)	127 (33.6%)
Medium	146 (41.8%)	125 (41.1%)	134 (32.2%)	115 (30.4%)
High	105 (30.1%)	96 (31.6%)	144 (34.6%)	136 (36.0%)
Distance to Water Source (N (%))				
Within Household Compound	176 (50.3%)	154 (50.7%)	247 (59.2%)	221 (58.5%)
Less Than Five Minutes	69 (19.7%)	58 (19.1%)	56 (13.4%)	49 (13.0%)
Five to Ten Minutes	42 (12.0%)	39 (12.8%)	40 (9.6%)	38 (10.1%)
More than Ten Minutes	63 (18.0%)	53 (17.4%)	74 (17.7%)	70 (18.5%)
Caste/Ethnicity (N (%))				
Dalit	87 (24.9%)	79 (26.0%)	103 (24.7%)	93 (24.6%)
Disadvantaged Janajatis	22 (6.3%)	19 (6.3%)	32 (7.7%)	27 (7.1%)
Disadvantaged Terai Castes	65 (18.6%)	62 (20.4%)	85 (20.4%)	84 (22.2%)
Religious Minorities	53 (15.1%)	48 (15.8%)	61 (14.6%)	59 (15.6%)
Advantaged Janajatis	16 (4.6%)	15 (4.9%)	20 (4.8%)	17 (4.5%)
Upper Caste	107 (30.6%)	81 (26.6%)	116 (27.8%)	98 (25.9%)
Index Mother's Complementary Feeding Knowledge (CFK) Score (Mean (SD))	1.1 (1.0)	1.1 (1.0)	0.8 (1.0)	0.8 (1.0)
Index Mother's Household Decision-Making Participation (HDMP) Score (Mean (SD))	5.9 (2.9)	5.8 (2.9)	5.9 (2.8)	5.8 (2.8)
Gender of Index Child (N (%))				
Male	200 (57.1%)	183 (60.2%)	248 (59.5%)	237 (62.7%)
Female	150 (42.9%)	121 (39.8%)	169 (40.5%)	141 (37.3%)
Average Age in Months of Index Child (Mean (SD))	33.9 (15.7)	34.1 (14.5)	38.1 (19.6)	38.8 (18.3)

Table 7. Descriptive statistics for children's weekly consumption frequency of vitamin A-rich fruits and vegetables, eggs, meat, and dairy assessed at up to four timepoint per household (back to text)

N = 1,449	Mean (SD)	Median (IQR)	Range	Missing
Vitamin A-Rich Fruits & Vegetables	3.6 (4.7)	2 (0-5)	0-36	0
Eggs	1.1 (1.9)	0 (0-2)	0-14	0
Meat	1.3 (1.7)	1 (0-2)	0-14	1
Dairy	5.3 (7.9)	0 (0-7)	0-44	1

Table 8. Descriptive statistics for household fruit and vegetable production and livestock ownership practices (back to text)

Total Observations	1,449
Production/Livestock Ownership	
Fruit & Vegetable Production	
Households producing any fruits and vegetables (N (%))	759 (52.4%)
Amount produced among fruit and vegetable producing households (median (IQR))	32 (15-81)
Production Categories (N (%))	
None	603 (41.6%)
Low (1-15 kg)	201 (13.9%)
Medium (16-81 kg)	370 (25.5%)
High (over 81 kg)	188 (13.0%)
Observations with missing data (N (%))	87 (6.0%)
Poultry Ownership	
Households owning any poultry (N (%))	517 (35.7%)
Number owned among poultry owning households (median (IQR))	3 (2-7)
Production Categories (N (%))	
None	932 (64.3%)
Low (1-2 birds)	220 (15.2%)
Medium (3-7 birds)	173 (11.9%)
High (8 or more birds)	124 (8.6%)
Observations with missing data (N (%))	0 (0.0%)
Meat Animal Ownership*	
Households owning any meat animals (N (%))	977 (67.4%)
Number owned among meat animal owning households (median (IQR))	4 (2-7)
Production Categories (N (%))	
None	472 (32.6%)
Low (1-2 animals)	311 (21.5%)
Medium (3-7 animals)	425 (29.3%)
High (8 or more animals)	241 (16.6%)
Observations with missing data (N (%))	0 (0.0%)
Cattle Ownership	
Households owning any cattle (N (%))	1023 (70.6%)
Number owned among cattle owning households (median (IQR))	2 (1-4)
Production Categories (N (%))	
None	531 (36.6%)
Low (1 cattle)	188 (13.0%)
Medium (2-4 cattle)	552 (38.1%)
High (5 or more cattle)	178 (12.3%)
Observations with missing data (N (%))	0 (0.0%)
*Meat animals include: poultry, goats, guinea fowl or pigeons, pigs, and rabbits	

Table 9. Descriptive statistics for household 30-day expenditure on vitamin a-rich fruits and vegetables, eggs, meat, and dairy (back to text)

Total Observations	1,449
Expenditure	
Expenditure on Vitamin A-Rich Fruits and Vegetables	
Households purchasing any vitamin A-rich fruits and vegetables (N (%))	523 (36.1%)
Amount spent among purchasing households (median (IQR)) NPR	200 (100-400)
Production Categories (N (%))	
None	926 (63.9%)
Low (1-100 NPR)	156 (10.8%)
Medium (101-400 NPR)	241 (16.6%)
High (over 400 NPR)	126 (8.7%)
Observations with missing data (N (%))	0 (0.0%)
Expenditure on Eggs	
Households purchasing any eggs (N (%))	501 (34.6%)
Amount spent among purchasing households (median (IQR)) NPR	180 (100-300)
Production Categories (N (%))	
None	948 (65.4%)
Low (1-100 NPR)	178 (12.3%)
Medium (101-300 NPR)	208 (14.4%)
High (over 300 NPR)	115 (7.9%)
Observations with missing data (N (%))	0 (0.0%)
Expenditure on Meat*	
Households purchasing any meat (N (%))	1209 (83.4%)
Amount spent among purchasing households (median (IQR)) NPR	1000 (600-1900)
Production Categories (N (%))	
None	240 (16.6%)
Low (1-600 NPR)	335 (23.1%)
Medium (601-1900 NPR)	577 (39.8%)
High (over 1900 NPR)	297 (20.5%)
Observations s with missing data (N (%))	0 (0.0%)
Expenditure on Milk	
Households purchasing any milk (N (%))	440 (30.4%)
Amount spent among purchasing households (median (IQR)) NPR	400 (180-710)
Production Categories (N (%))	
None	1009 (69.6%)
Low (1-180 NPR)	111 (7.7%)
Medium (181-710 NPR)	219 (15.1%)
High (over 710 NPR)	110 (7.6%)
Observations with missing data (N (%))	0 (0.0%)
*Includes expenditure on poultry, goat, buffalo, and pork meat	

Table 10. Negative binomial generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as incident rate ratios (IRR) and 95% confidence intervals (95% CI), between predictor variables of interest and children's weekly consumption frequency of vitamin A-rich fruits and vegetables (back to text)

	Consumption Frequency of Vitamin A-Rich Fruits & Vegetables N = 1361	
	Bivariates	**Multivariate[1]**
	IRR (95% CI)	IRR (95% CI)
Fruit & Vegetable Production		
None	1.0	1.0
Low (1-15 kg)	1.2 (1-1.5)	1.5 (1.2-1.8)***
Medium (16-81 kg)	1.4 (1.2-1.6)***	1.7 (1.4-2.0)***
High (over 81 kg)	1.5 (1.3-1.8)***	1.9 (1.5-2.3)***
Expenditure		
None	1.0	1.0
Low (1-100 NPR)	0.8 (0.6-1.0)	0.9 (0.7-1.1)
Medium (101-400 NPR)	1.5 (1.3-1.8)***	1.6 (1.3-1.9)***
High (over 400 NPR)	2.0 (1.6-2.4)***	2.2 (1.8-2.8)***
Caste/Ethnicity		
Dalit	1.0	1.0
Disadvantaged Janajatis	1.0 (0.8-1.3)	0.9 (0.7-1.2)
Disadvantaged Terai Castes	0.9 (0.7-1.2)	0.9 (0.8-1.2)
Religious Minorities	1.2 (0.9-1.5)	1.3 (1-1.7)*
Advantaged Janajatis	0.7 (0.5-1.0)	0.7 (0.5-1)*
Upper Caste	1.5 (1.2-1.8)***	1.1 (0.9-1.3)
Mother's CFK Score	1.2 (1.1-1.2)***	1.1 (1.1-1.2)***
Mother's HDMP Score	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Constant	--	1.2 (0.9-1.7)

*= $p < 0.05$; **= $p < 0.01$; ***= $p < 0.001$

[1]Also adjusted for child gender and age

Table 11. Negative binomial generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as incident rate ratios (IRR) and 95% confidence intervals (95% CI), between predictor variables of interest and children's weekly consumption frequency of eggs (back to text)

	Consumption Frequency of Eggs N = 1448	
	Bivariates	**Multivariate[1]**
	IRR (95% CI)	IRR (95% CI)
Poultry Ownership		
None	1.0	1.0
Low (1-2 birds)	1.6 (1.3-2.1)***	2.8 (2.1-3.6)***
Medium (3-7 birds)	1.3 (0.9-1.7)	1.9 (1.3-2.6)***
High (8 or more birds)	1.3 (0.9-1.9)	1.8 (1.2-2.8)**
Expenditure		
None	1.0	1.0
Low (1-100 NPR)	1.8 (1.4-2.4)***	2.4 (1.8-3.1)***
Medium (101-300 NPR)	2.9 (2.3-3.8)***	4 (3.1-5.1)***
High (over 300 NPR)	5.3 (4-7.1)***	7 (5.3-9.4)***
Caste/Ethnicity		
Dalit	1.0	1.0
Disadvantaged Janajatis	1.4 (0.8-2.4)	1.2 (0.7-1.8)
Disadvantaged Terai Castes	0.8 (0.5-1.1)	0.9 (0.6-1.2)
Religious Minorities	1.5 (1.1-2.2)*	1.2 (0.9-1.7)
Advantaged Janajatis	1.1 (0.7-1.8)	0.9 (0.5-1.5)
Upper Caste	1.7 (1.3-2.4)***	1.4 (1.0-1.9)*
Mother's CFK Score	1.0 (0.9-1.1)	1.0 (0.9-1.1)
Mother's HDMP Score	1.0 (1.0-1.1)	1.0 (1.0-1.0)
Constant	--	0.3 (0.2-0.5)
*= p < 0.05; **= p < 0.01; ***= p < 0.001		
[1]Also adjusted for child gender and age		

Table 12. Negative binomial generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as incident rate ratios (IRR) and 95% confidence intervals (95% CI), between predictor variables of interest and children's weekly consumption frequency of meat (back to text)

	Consumption Frequency of Meat N = 1447	
	Bivariates	**Multivariate[1]**
	IRR (95% CI)	IRR (95% CI)
Meat Animal Ownership		
None	1.0	1.0
Low (1-2 animals)	1.1 (0.9-1.4)	1.2 (1.0-1.4)
Medium (3-7 animals)	1.1 (0.9-1.3)	1.1 (0.9-1.3)
High (8 or more animals)	1.5 (1.2-1.8)***	1.4 (1.1-1.7)***
Expenditure		
None	1.0	1.0
Low (1-600 NPR)	2.5 (1.8-3.5)***	2.4 (1.7-3.3)***
Medium (601-1900 NPR)	3.3 (2.4-4.4)***	2.8 (2.0-3.8)***
High (over 1900 NPR)	5.5 (4.0-7.5)***	4.5 (3.3-6.3)***
Caste/Ethnicity		
Dalit	1.0	1.0
Disadvantaged Janajatis	0.9 (0.7-1.1)	0.8 (0.6-1.0)
Disadvantaged Terai Castes	0.3 (0.2-0.4)***	0.4 (0.3-0.5)***
Religious Minorities	0.5 (0.4-0.7)***	0.6 (0.5-0.8)***
Advantaged Janajatis	0.9 (0.7-1.2)	0.9 (0.7-1.2)
Upper Caste	0.8 (0.6-0.9)*	0.7 (0.6-0.8)***
Mother's CFK Score	1.1 (1.0-1.1)	1.0 (1.0-1.1)
Mother's HDMP Score	1.0 (1.0-1.0)	1.0 (1.0-1.0)
Constant	--	0.4 (0.2-0.5)
*= p < 0.05; **= p < 0.01; ***= p < 0.001		
[1]Also adjusted for child gender and age		

Table 13. Negative binomial generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as incident rate ratios (IRR) and 95% confidence intervals (95% CI), between predictor variables of interest and children's weekly consumption frequency of dairy (back to text)

	Consumption Frequency of Dairy N = 1447	
	Bivariates	**Multivariate[1]**
	IRR (95% CI)	IRR (95% CI)
Cattle Ownership		
None	1.0	1.0
Low (1 cow or buffalo)	1.6 (1.2-2.1)***	2.0 (1.5-2.6)***
Medium (2-4 cattle)	2.2 (1.8-2.8)***	2.8 (2.2-3.7)***
High (5 or more cattle)	2.7 (2.1-3.5)***	3.3 (2.4-4.4)***
Expenditure		
None	1.0	1.0
Low (1-180 NPR)	0.5 (0.4-0.7)***	0.8 (0.6-1.1)
Medium (181-710 NPR)	1.0 (0.8-1.2)	1.4 (1.1-1.9)**
High (over 710 NPR)	1.7 (1.4-2.1)***	2.5 (2.0-3.1)***
Caste/Ethnicity		
Dalit	1.0	1.0
Disadvantaged Janajatis	2.5 (1.8-3.5)***	2.3 (1.7-3.2)***
Disadvantaged Terai Castes	1.1 (0.8-1.5)	1.1 (0.8-1.5)
Religious Minorities	0.5 (0.3-0.8)**	0.5 (0.3-0.8)**
Advantaged Janajatis	2.1 (1.4-3.2)***	1.8 (1.2-2.7)**
Upper Caste	2.3 (1.7-3.0)***	2.0 (1.5-2.7)***
Mother's CFK Score	1.0 (0.9-1.1)	0.9 (0.9-1.1)
Mother's HDMP Score	1.0 (1.0-1.0)	1.0 (0.9-1.0)
Constant	--	3.3 (1.4-3.7)
*= p < 0.05; **= p < 0.01; ***= p < 0.001		
[1]Also adjusted for child gender and age		

Table 14. Logistic generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as odds ratios (OR) and 95% confidence intervals (95% CI), between predictor variables of interest and odds of a household producing any fruits and vegetables/ livestock, vs. no fruit and vegetable/livestock production (back to text)

	Fruit and Vegetable Production N = 1361		**Poultry Ownership N = 1448**		**Meat Animal Ownership N = 1448**		**Cattle Ownership N = 1448**	
	Biv.	**Mult.**	**Biv.**	**Mult.**	**Biv.**	**Mult.**	**Biv.**	**Mult.**
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Season								
Summer	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Winter	1.1 (0.9-1.3)	0.2 (0.1-0.3)***	1.1 (0.9-1.3)	1.2 (0.8-1.8)	1.0 (0.8-1.0.1.0)	1.0 (0.7-1.5)	1.8 (1.5-2.2)***	4.7 (3.1-7.3)***
Region								
Mountains	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Hills	14.1 (9.2-21.7)***	5.8 (3.1-10.9)***	4.1 (2.8-6.1)***	2.8 (1.7-4.5)***	11 (6.8-17.8)***	9.6 (5.4-17.1)***	3.6 (2.3-5.6)***	7 (3.9-12.5)***
Terai (plains)	0.5 (0.3-0.6)***	0.2 (0.1-0.4)***	0.8 (0.5-1.2)	0.7 (0.3-1.9)	3.3 (2.3-4.8)***	2.6 (1.1-5.9)*	1.3 (0.9-1.9)	1.6 (0.7-3.4)
Region*Season Interaction								
Hills*Winter	--	9.1 (3.4-24.1)***	--	1.0 (0.6-1.6)	--	0.9 (0.5-1.4)	--	0.3 (0.1-0.5)***
Terai (plains)*Winter	--	15.8 (8.6-29.2)***	--	0.7 (0.4-1.2)	--	0.8 (0.5-1.3)	--	0.3 (0.2-0.5)***
Wealth Tertile								
Low	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Medium	1.6 (1.2-2.2)**	1.2 (0.8-1.8)	1.4 (1.0-1.9)*	1.4 (0.9-2)	1.3 (1.0-1.7)	1.2 (0.9-1.7)	0.9 (0.7-1.2)	0.7 (0.5-1.1)
High	2.3 (1.7-3.1)***	1.4 (0.9-2.2)	1.7 (1.2-2.3)**	1.5 (1.0-2.5)	1.4 (1.0-1.9)	1.1 (0.7-1.6)	1.0 (0.7-1.3)	0.6 (0.4-1.0)
Land Tertile								
Low	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Medium	1.8 (1.3-2.6)***	1.3 (0.9-1.9)	1.3 (0.9-1.8)	1.1 (0.7-1.7)	1.7 (1.2-2.5)**	1.4 (1-2.2)	1.0 (0.7-1.5)	0.8 (0.5-1.2)
High	2.9 (2-4.2)***	1.8 (1.2-2.7)**	1.8 (1.2-2.7)**	1.4 (0.9-2.2)	2.6 (1.7-3.9)***	1.9 (1.2-2.9)**	3.9 (2.5-6.1)***	3.3 (2-5.3)***
Distance to Water Source								
Within Household	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
< 5 Min.	1.4 (1.0-1.9)	0.8 (0.5-1.3)	1.3 (0.9-1.8)	1.2 (0.8-1.8)	0.8 (0.6-1.1)	0.8 (0.5-1.2)	1.1 (0.8-1.4)	0.9 (0.6-1.4)
5-10 Min.	1.2 (0.8-1.7)	0.6 (0.3-1.0)*	1.5 (1.1-2.2)*	1.4 (0.9-2.4)	1.0 (0.7-1.5)	1.1 (0.7-1.7)	1.2 (0.9-1.7)	1.0 (0.7-1.6)
> 10 Min.	1.4 (1.0-1.9)*	0.5 (0.3-0.9)*	1.5 (1.0-2.2)*	1.4 (0.8-2.2)	0.9 (0.6-1.3)	0.9 (0.5-1.4)	1.1 (0.8-1.5)	0.8 (0.5-1.2)
Caste/Ethnicity								

Dalit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Disadvantaged Janajatis	3 (1.4-6.2)**	1.1 (0.5-2.2)	4.4 (2.1-9.3)***	3.6 (1.6-8.1)**	8.5 (2.4-30.2)***	4.3 (1.4-13.3)*	0.7 (0.4-1.5)	0.4 (0.2-1.0)*
Disadvantaged Terai Castes	0.4 (0.2-0.5)***	0.8 (0.5-1.6)	0 (0-0.1)***	0.1 (0-0.4)**	1.2 (0.8-2)	1.1 (0.5-2.6)	0.9 (0.6-1.5)	1.2 (0.5-2.6)
Religious Minorities	0.2 (0.1-0.3)***	0.5 (0.2-0.9)*	1.3 (0.8-2)	3.7 (1.4-9.5)**	1.5 (0.9-2.4)	1.6 (0.7-3.7)	0.6 (0.3-0.9)*	0.9 (0.4-2)
Advantaged Janajatis	6.7 (2.7-16.8)***	1.2 (0.3-4.7)	2.7 (1.2-5.8)*	1.7 (0.8-3.8)	2.8 (1.1-7.5)*	0.9 (0.3-2.2)	2.5 (1.0-6.4)	1.4 (0.5-3.7)
Upper Caste	2.1 (1.4-3.1)***	1.9 (1.2-3.1)**	0.8 (0.5-1.2)	0.8 (0.5-1.2)	1.0 (0.6-1.5)	1.0 (0.6-1.6)	0.9 (0.6-1.4)	1.2 (0.7-2)
Mother's CFK Score	1.0 (0.9-1.1)	0.9 (0.8-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.2)	0.9 (0.8-1.0)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.2)
Mother's HDMP Score	1.1 (1.0-1.1)*	1.0 (1.0-1.1)	1.0 (0.9-1.0)	1.0 (0.9-1.0)	0.9 (0.9-1.0)*	1.0 (0.9-1.0)	0.9 (0.9-1.0)***	0.9 (0.8-0.9)***
Constant	--	1.2 (0.5-2.5)	--	0.3 (0.1-0.6)	--	0.6 (0.3-1.2)	--	2.0 (.01-4.1)

*= p < 0.05; **= p < 0.01; ***= p < 0.001

Table 15. Logistic generalized estimating equation regression results showing estimated population-averaged bivariate and multivariate relationships, presented as odds ratios (OR) and 95% confidence intervals (95% CI), between predictor variables of interest and odds of a household having medium or high 30-day expenditure vs. none or low expenditure on vitamin A-rich fruits and vegetables, eggs, meat, and dairy (back to text)

	Expenditure on Vitamin A-Rich Fruits & Vegetables N = 1361		Expenditure on Eggs N = 1448		Expenditure on Meat N = 1448		Expenditure on Dairy N = 1448	
	Biv.	**Mult.**	**Biv.**	**Mult.**	**Biv.**	**Mult.**	**Biv.**	**Mult.**
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Production								
None	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Any	0.4 (0.3-0.6)***	0.7 (0.5-1.0)*	0.6 (0.5-0.8)***	0.6 (0.4-0.8)**	1.1 (0.9-1.4)	1.2 (0.9-1.5)	0.6 (0.4-0.8)***	0.5 (0.4-0.8)***
Season								
Summer	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Winter	0.1 (0.1-0.2)***	0.3 (0.2-0.4)***	1.0 (0.8-1.3)	0.8 (0.5-1.1)	1.0 (0.8-1.2)	1.3 (0.9-2.0)	1.1 (0.9-1.4)	1.4 (0.9-2.2)
Region								
Mountains	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Hills	0.3 (0.2-0.5)***	0.4 (0.2-0.7)***	0.5 (0.3-0.8)**	0.5 (0.3-0.8)**	1.2 (0.8-1.7)	1.4 (0.8-2.2)	0.7 (0.5-1.1)	1.0 (0.6-1.8)
Terai (plains)	1.1 (0.8-1.5)	1.4 (0.5-3.5)	0.8 (0.6-1.2)	1.1 (0.5-2.5)	0.2 (0.2-0.3)***	0.3 (0.2-0.7)**	1.3 (0.9-1.9)	3.5 (1.8-6.9)***
Region*Season Interaction								
Hills*Winter	--	0.2 (0.1-0.8)*	--	1.1 (0.6-2.0)	--	0.5 (0.3-1.0)	--	0.8 (0.4-1.5)
Terai (plains)*Winter	--	0.2 (0.1-0.4)***	--	1.9 (1.1-3.2)*	--	0.9 (0.5-1.5)	--	0.9 (0.5-1.7)
Wealth Tertile								
Low	1 (0-0)	1 (0-0)	1 (0-0)	1 (0-0)	1 (0-0)	1 (0-0)	1 (0-0)	1 (0-0)
Medium	1.8 (1.3-2.4)***	2.2 (1.4-3.3)***	1.4 (1-2.1)	1.6 (1.1-2.4)*	1.7 (1.2-2.3)**	1.6 (1.2-2.3)**	2.1 (1.5-3.0)***	2.4 (1.6-3.6)***
High	2.2 (1.6-3.0)***	3.7 (2.3-5.9)***	2.7 (1.9-3.9)***	3.2 (2.1-4.8)***	3.0 (2.2-4.2)***	2.9 (2-4.1)***	3.6 (2.5-5.1)***	4.2 (2.8-6.4)***
Caste/Ethnicity								
Dalit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Disadvantaged Janajatis	1.2 (0.6-2.6)	1.1 (0.4-2.9)	1.4 (0.7-2.9)	1.3 (0.6-2.5)	1.3 (0.7-2.4)	1.1 (0.5-2.2)	1.6 (0.8-3.2)	0.8 (0.4-1.6)
Disadvantaged Terai Castes	3.1 (2.1-4.5)***	2.3 (0.9-5.9)	1.4 (0.8-2.2)	0.5 (0.2-1.3)	0.2 (0.1-0.3)***	0.4 (0.2-0.7)**	2.1 (1.3-3.4)**	0.7 (0.3-1.3)

Religious Minorities	2.6 (1.7-4.0)***	1.7 (0.7-4.6)	1.8 (1.1-3.1)*	0.9 (0.4-2.1)	0.3 (0.2-0.5)***	0.7 (0.3-1.3)	2.0 (1.2-3.3)*	0.6 (0.3-1.1)
Advantaged Janajatis	0.5 (0.2-1.5)	0.4 (0.1-1.6)	1.9 (0.9-4.1)	1.9	0.8 (0.5-1.5)	0.5	0.6 (0.2-1.7)	0.4
Upper Caste	2.3 (1.5-3.4)***	1.8 (1.1-2.8)*	2.1 (1.4-3.4)**	1.4 (0.9-2.3)	1.2 (0.8-1.8)	0.9 (0.6-1.3)	2.3 (1.5-3.6)***	1.6 (1.0-2.5)*
Mother's CFK Score	1.2 (1.1-1.3)**	1.1 (0.9-1.3)	1.1 (1.0-1.2)	1.0 (0.8-1.1)	1.1 (1-1.2)	1.0 (0.9-1.2)	1.1 (1-1.3)	1.0 (0.9-1.2)
Mother's HDMP Score	1.0 (0.9-1.0)*	1.0 (0.9-1.0)	1.0 (1.0-1.1)	1.1 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (0.9-1.0)	1.0 (1.0-1.1)	1.0 (1.0-1.1)
Constant	--	0.4 (0.2-0.7)**	--	0.2 (0.1-0.3)***	--	2.2 (1.2-3.8)**	--	0.1 (0.0-0.1)***
*= p < 0.05; **= p < 0.01; ***= p < 0.001								

Table 16. Summary of analysis findings and their implications for each of the three research questions regarding consumption frequency, production, and purchasing (back to text)

Outcome Examined	Summary of Findings	Overall Implications
Children's weekly consumption frequency of vitamin A-rich fruits and vegetables, eggs, meat, and dairy	• Production/livestock ownership associated with greater consumption for all food groups • Greater expenditure associated with greater consumption for all food groups • Associations between caste/ethnicity and consumption vary depending on food group • Small positive association between mothers' nutrition knowledge and consumption for vitamin A-rich fruits and vegetables only • No association between women's decision-making power and children's consumption, or evidence of interaction between decision-making power and nutrition knowledge	• Greater household production of and expenditure on non-staple nutritious foods is strongly associated with greater consumption frequency by children • Environmental factors and resource access are important determinants of household production of and expenditure on non-staple nutritious foods • Production, purchasing, and children's consumption of specific food types vary by caste/ethnicity, but there are no caste/ethnic groups consistently more or less likely to produce, purchase, or consume all food types. • Household food access (whether via production or expenditure) is much more strongly associated with children's consumption frequency of non-staple nutritious foods, and contextual factors are much more strongly associated with production or purchasing of non-staple nutritious foods, compared to mothers' nutrition knowledge and decision-making power
Household fruit and vegetable production and ownership of poultry, meat animals, and cattle	• Differences by region for all production/livestock ownership outcomes, with higher likelihood of production/livestock ownership in the hills; direction and magnitude of differences between the mountains and plains vary by outcome • Region-specific differences by season for fruit and vegetable production and cattle ownership • Greater land ownership associated with greater likelihood of production/livestock ownership, with the exception of poultry • Distance to water associated with decreased likelihood of fruit and vegetable production • Associations between caste/ethnicity and production vary depending on outcome • No association between mothers' nutrition knowledge and production/livestock ownership, or evidence of interaction between decision-making power and nutrition knowledge • Small negative association between mothers' decision-making power and likelihood of cattle ownership	
Household expenditure on vitamin A-rich fruits and vegetables, eggs, meat, and dairy	• Differences by region for all expenditure types; direction and magnitude of differences vary by food group • Differences by season for expenditure on vitamin A-rich fruits and vegetables in all regions • Greater wealth significantly associated with greater likelihood of expenditure for all food groups • No association between mothers' nutrition knowledge or decision-making power and expenditure or evidence of interaction between decision-making power and nutrition knowledge	

5.9 Figures for Chapter 6

Figure 12. Conceptual model showing the theorized relationships between household production and purchasing and children's consumption frequency of non-staple nutritious foods, as well as between contextual factors and household production and purchasing (back to text)

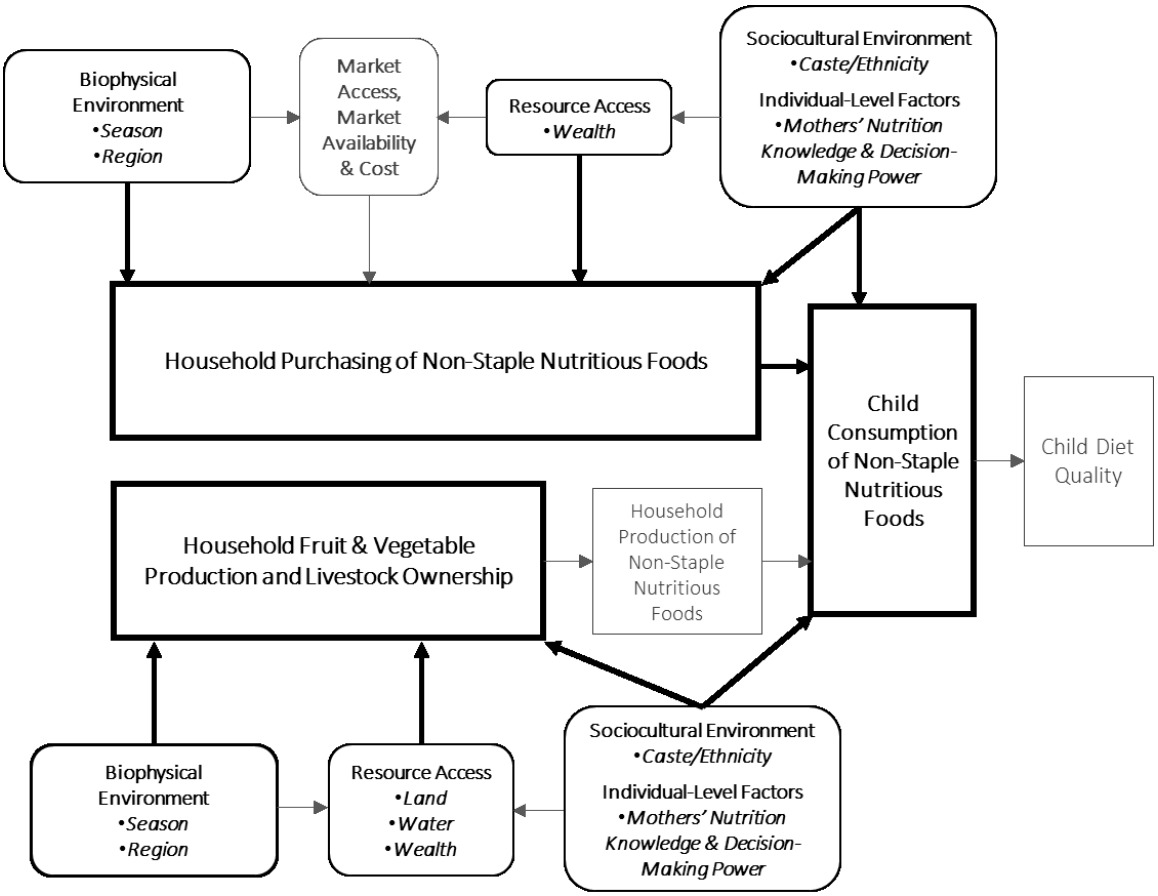


Figure 13. Flow diagram showing selection of analysis sample from PoSHAN study population (back to text)

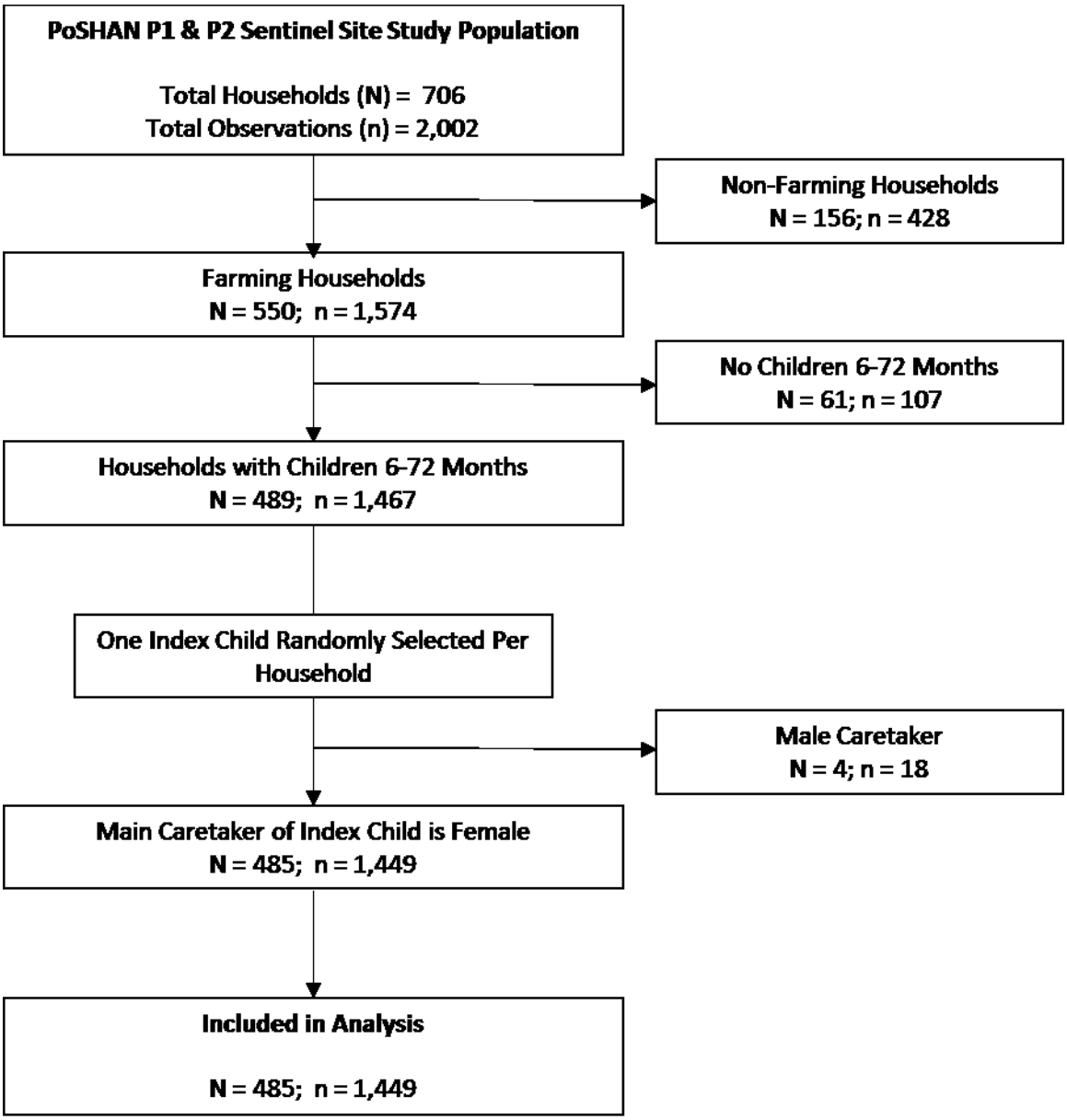


Figure 14. Household non-staple nutritious food production and purchasing practices in 30-days prior to survey timepoint, by region (back to text)

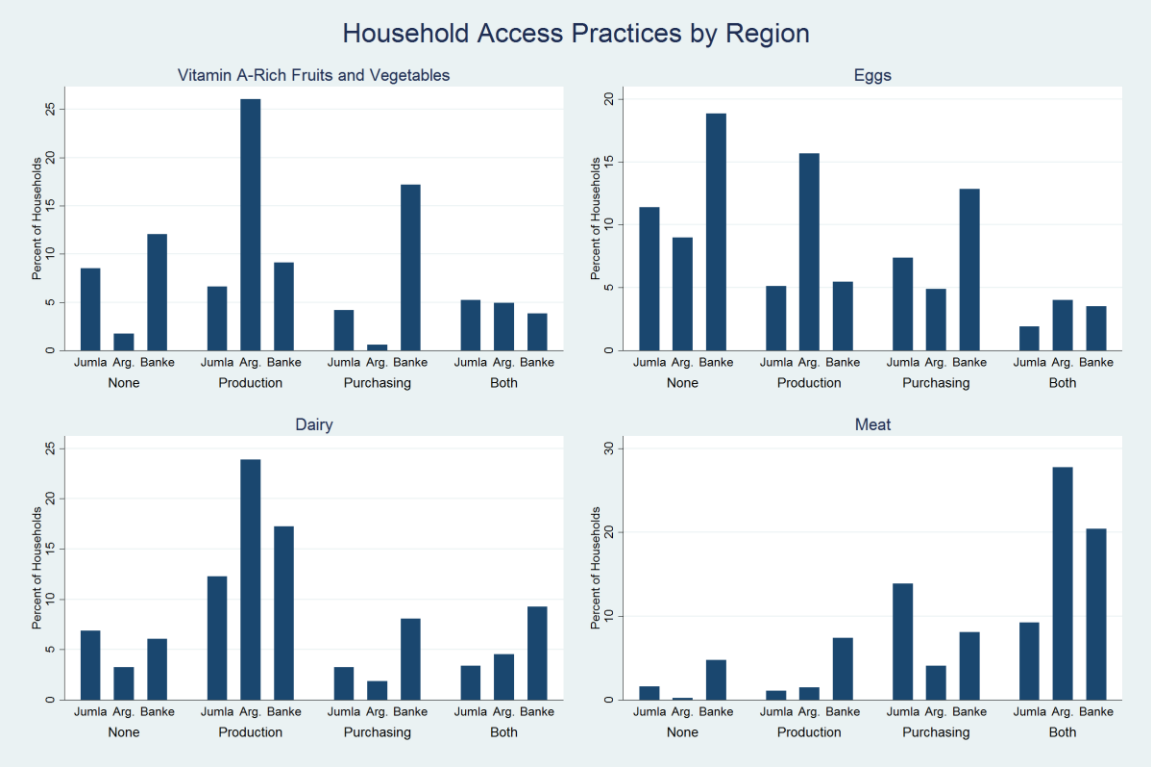


Figure 15. Household non-staple nutritious food production and purchasing practices in 30-days prior to survey timepoint, by season (back to text)

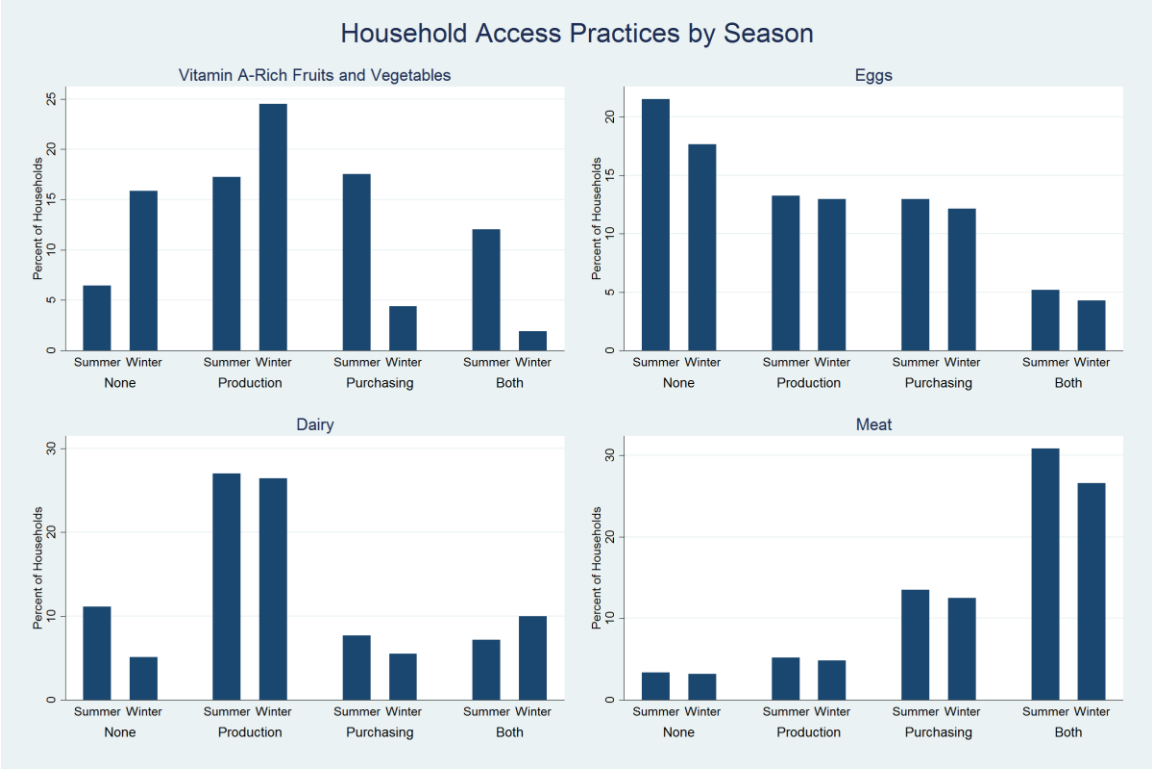


Figure 16. Marginal plots showing children's predicted average weekly consumption frequency (with 95% confidence interavels) of vitamin A-rich fruits and vegetables, eggs, meat, and dairy at different levels of production and consumption (back to text)

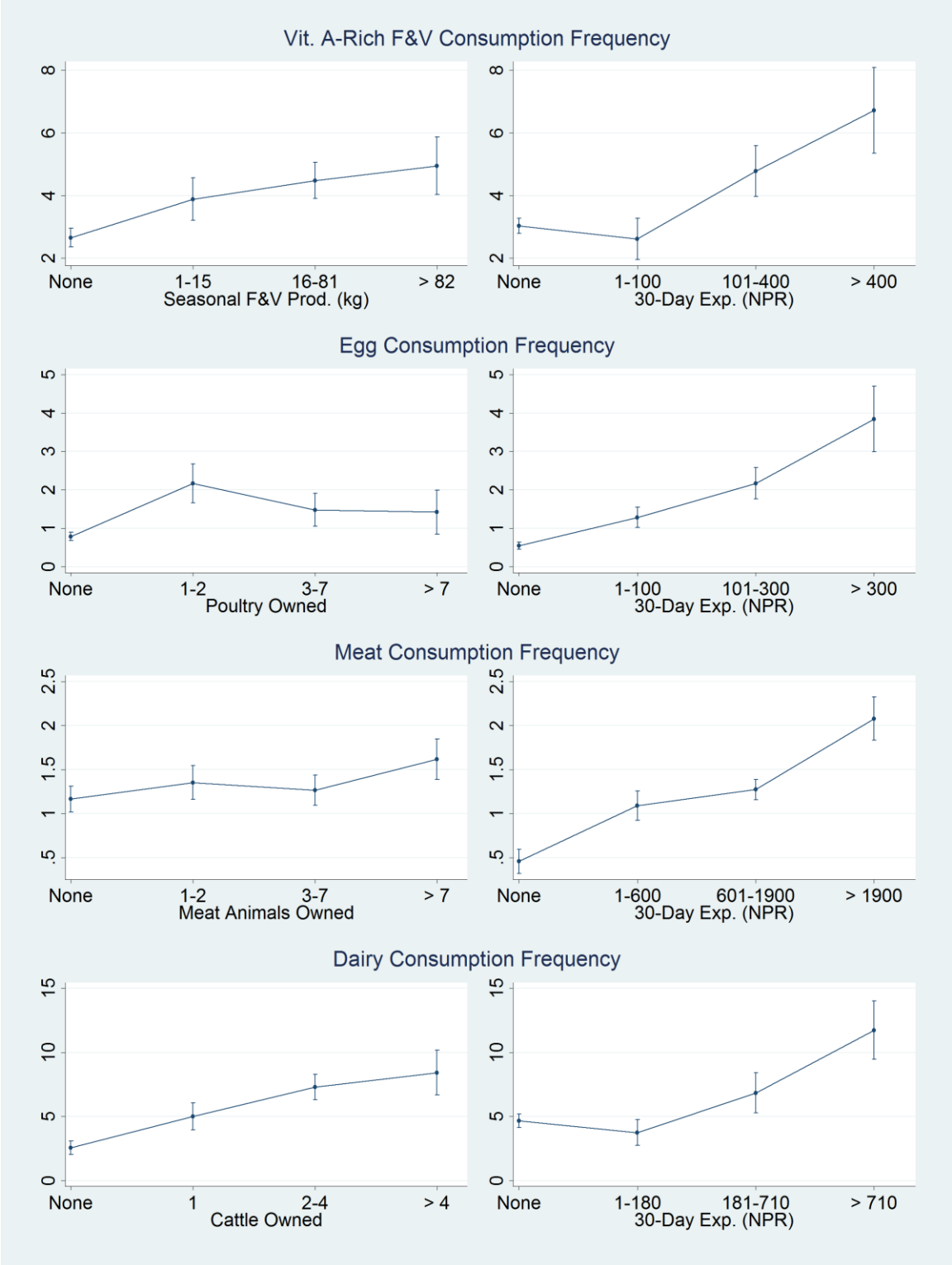


Figure 17. Marginal plots showing predicted average probability of households producing fruits and vegetables, owning poultry, owning meat animals, or owning cattle by season and by region (back to text)

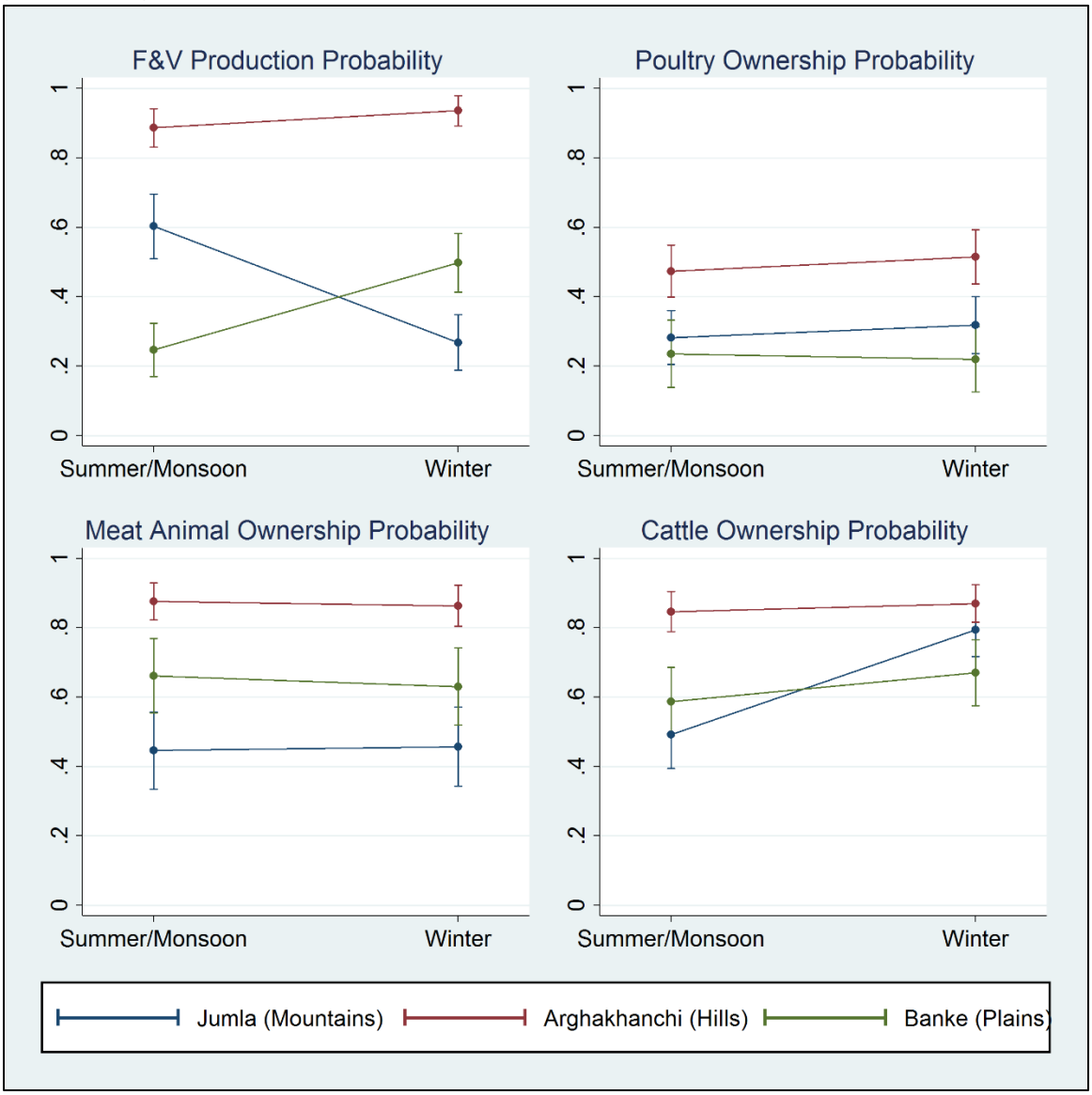
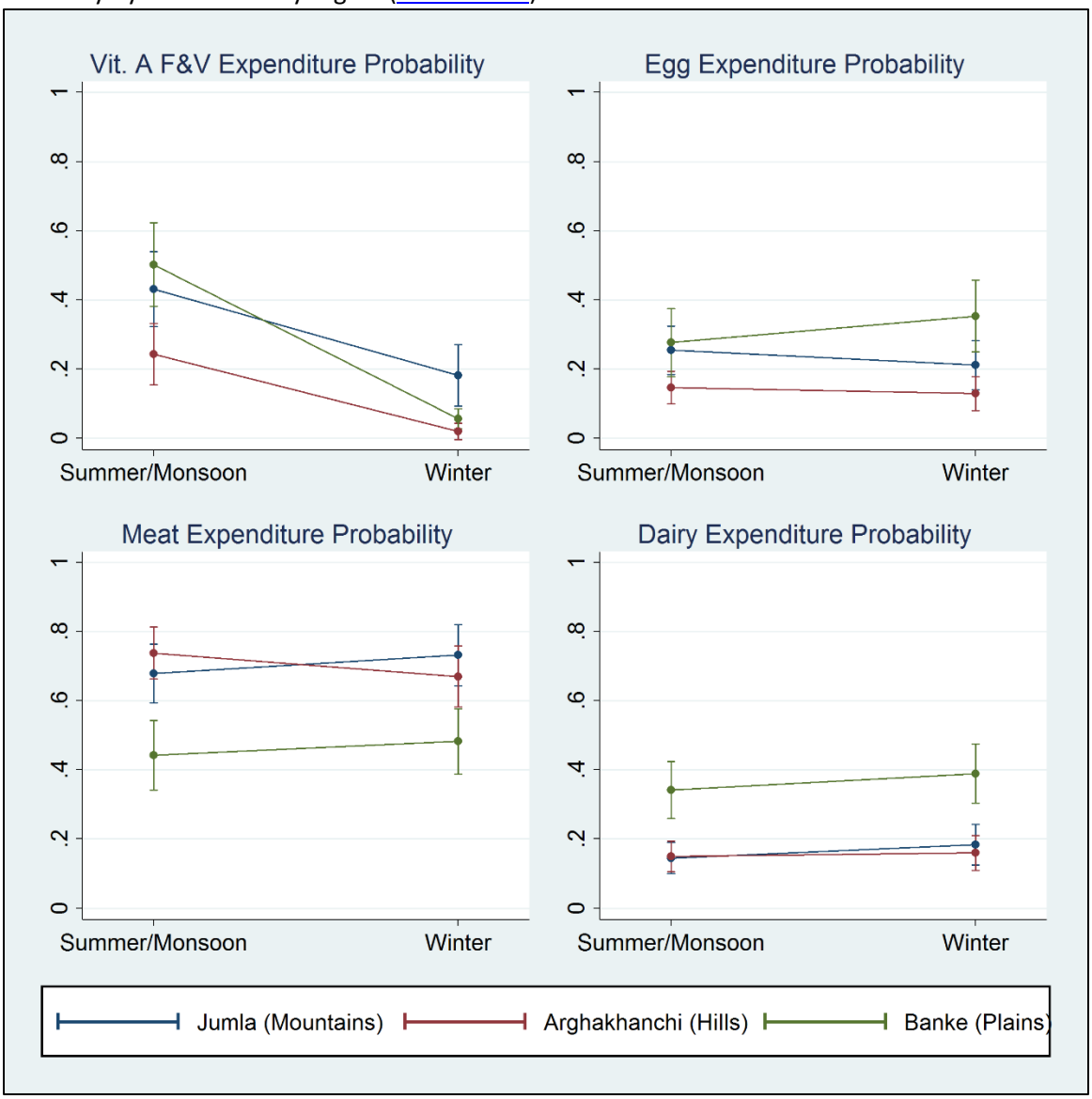


Figure 18. Marginal plots showing predicted average probability of households having medium or high (vs. low or none) 30-day expenditure on vitamin A-rich fruits and vegetables, eggs, meat, and dairy by season and by region (back to text)



Chapter 6. Water, land, and time: navigating the structural barriers to implementation of an integrated nutrition program in far-Western Nepal

6.1 Abstract

Background: Nutrition-sensitive agriculture programs hold substantial promise for improving access to nutritious food in contexts like rural Nepal. Yet, the complexity of such programs makes their implementation at scale challenging, particularly in a highly geographically and culturally diverse country like Nepal. Increasingly, experts call for greater attention to the contextual factors which influence their implementation.

Methods: I conducted qualitative implementation research examining the agricultural components of an integrated nutrition program in one of Nepal's least food secure and most remote districts. I aimed to identify contextual factors that influenced participants' abilities to engage in and benefit from the program. While shadowing program staff over the course of three months, I conducted interviews with program participants (n=31) and staff (n=11), and three focus-group discussions with female community health volunteers (n=28). I also took extensive field notes describing observation of the proceedings of program activities and agricultural practices throughout the district. An integrated food and nutrition system framework guided thematic analysis.

Findings: Program participants demonstrated high levels of knowledge about the program's key nutrition messages and expressed interest in and motivation to engage in the agricultural components. However, access to water, land, and time determined the extent to which participation was feasible. Factors within the biophysical and sociocultural environments, as well as historic and current land and labor policies, interacted to influence access to these crucial resources. Program participants and staff provided examples of several different strategies

employed to navigate resource-related barriers, including: investing in micro-irrigation equipment, arranging land-sharing agreements, and engaging families and modeling more equitable gender norms. Feasibility of these strategies also varied substantially depending on context.

Conclusions: Successfully implementing nutrition-sensitive agriculture programs in diverse settings will require addressing context-specific structural barriers, particularly if the program aims to benefit the most vulnerable. Strategies used by program participants and local staff to navigate resource-access barriers point towards potential ways to improve program design and implementation. However, long-term solutions to the barriers faced by the most marginalized households will require broad structural changes, including investment in irrigation infrastructure, equitable land reform, and establishment of robust social protection measures.

6.2 Introduction

6.2.1 Background

Nutrition-sensitive agriculture programs hold substantial promise for improving access to nutritious food in contexts like rural Nepal.[16] Interventions promoting "improved" kitchen gardens and small animal husbandry, such as Helen Keller International's Homestead Food Production (HFP) program, are one example. [15, 53-55] Improved gardens are those that produce multiple types of vegetables, fruits, and other crops on a year-round basis. Examples of inputs and activities include providing beneficiaries with high-quality seeds for crops suited to each season, providing small livestock like chicken or goats, and providing trainings on agricultural techniques and nutrition. Evaluations of HFP interventions suggest that they improve the amount and diversity of nutritious foods produced and consumed by mothers and children.[14, 59]

Increasingly, agriculture-nutrition program planners and researchers are asking how to effectively scale-up interventions across diverse settings, and thus seeking to understand the setting-specific factors that influence feasibility and implementation.[10, 18] As concluded by Arimond et al., to successfully plan and implement agriculture-nutrition interventions, "thorough and grounded knowledge of context is essential."[7] Yet, few previous studies have examined the contextual factors that influence implementation of nutrition-sensitive agriculture programs.[17]

In a recently published framework and research agenda for strengthening implementation and utilization of nutrition interventions, Menon et al. discuss the multiple levels at which contextual influences occur and emphasize their effects on demand, utilization, adherence, and sustainability.[19] They recommend several specific qualitative methods for exploring factors that influence implementation, including: interviews with community health workers, program staff, and mothers and "shadowing" of program staff.[19] Using these methods, this study examined implementation of the HFP component of an integrated nutrition program in one of Nepal's least food secure and most remote districts. The study aimed to identify contextual factors that influenced participants' abilities to engage in and benefit from the program.

6.2.2 Study Setting

Nepal's far-Western mountains region is one of the most remote and impoverished areas of the country. A long history of disenfranchisement and exploitation by the country's ruling elite has contributed to the entrenched poverty and food insecurity in this area, and fueled support for the 1990's Maoist insurgency. [64]This region was therefore heavily affected by violent conflict during the country's ten-year civil war that ended in 2006.[64, 65] Although access

to primary education has improved over the past decade, literacy rates are still very low, particularly among women.[1] Additionally, caste and gender-based power differences and discrimination persist here to a greater degree than in much of the rest of the country.[64]

The easternmost of the far-Western mountain region's three districts, Bajura, was the site for this study. The HFP program had been ongoing for three years there at the time of data collection. This meant that program participants and staff could speak to their experiences and challenges encountered with the program over a substantial amount of time. Additionally, Bajura's context encompasses extreme versions of many of the challenges likely to impact nutrition-sensitive agriculture program implementation throughout Nepal. The district's diverse landscape varies widely in terms of climate and topography, with elevation ranging from below 2,000 feet to over 12,000 feet. The population includes some of the most socially and economically marginalized groups in the country; it had the lowest human-development index score in Nepal at the time this study was carried out.[67] Caste groups that comprise the majority of the population are Chhetri (60%), Dalit (23%), Brahmin (10%), and Thakuri (6%).[68] Literacy rates demonstrate substantial gender disparities, with about 60% of men and only about 20% of women over the age of 15 considered literate.[68]

Bajura's one road enters the district from the south and reaches the district headquarters, but is impassable during the rainy season. A new road going north out of the district headquarters was under construction but not yet functional at the time of data collection. Less than a quarter of all households have electricity for lighting.[68] Most crops—primarily barley, wheat, corn, and in lower elevation areas rice—are rain-fed. Stone irrigation canals carry water to fields in some areas but rely on water sources that are also rain-fed, so during the winter they run dry. Only about two percent of Bajura's land is irrigated year-round.[68]

An estimated 60% of children in Bajura are stunted and a third of the population (which totals about 135,000) only produces enough food each year to last for three months or less.[68, 104] Nearly eight percent of Bajura's population is landless,[68] due to a long and complex history of land allocation and bonded labor systems that discriminated against Dalit and indigenous populations.[64, 100, 105] Historically, Dalits in far-western Nepal could not legally own land and were obliged to live as the tenants of higher-status caste households.[64, 105] Many were also impacted by haliya,[2] a system of bonded labor that was formally abolished in 2008.[106] About ten percent of Bajura's households had members working as laborers under the haliya system at that time.[68] The government stated that all freed laborers would be "rehabilitated," i.e. provided with land and job skill trainings. However, this has yet to happen, so many families are still reliant on working for those they were previously bonded to.[107] Seasonal labor migration to India or the Terai, usually by men, is common among households that can't meet their food needs with their own production. Because of the large up-front costs associated with arranging travel, few men from Bajura travel overseas to work in countries with more lucrative employment opportunities (such as Qatar, Dubai, or Malaysia) like many men from other parts of Nepal do.

6.2.3 Theoretical Perspective

The integrated food and nutrition system framework, described by Burchi et. al.,[9] provides a theoretical understanding of how context influences food production and consumption. This framework emphasizes the importance of three different domains: the

[2] Under haliya, households that owed a debt were obligated to work as bonded agricultural laborers for their creditors until the debt was repaid. Debts usually originated from high-interest loans taken by landless households to purchase food. With high interest rates and without land of their own to generate income, haliya laborers were often effectively bonded to their creditors indefinitely, frequently having to continue taking high-interest loans to survive. Debts were passed down from parent to child, meaning that labor obligations could persist for generations.

biophysical environment, the sociocultural environment, and policies and institutions. Each of these domains influences access to the resources needed for food production and consumption. Applied to the study's research question, this theoretical framework indicates that: 1) Access to key resources determines agriculture-sensitive nutrition program participants' abilities to engage in and benefit from the program; and 2) Factors within the biophysical and sociocultural environments and policies and institutions determine access to resources.

The concepts of agency and structure, classically articulated by sociologists Bourdieu,[21] Weber,[22] and Giddens,[23] also guided analysis and interpretation of the study's findings. Agency refers to free will and choice. Individuals exert agency when they choose to engage or not engage in behaviors based on their knowledge and preferences. Agency, however, is constrained by structure—i.e. social norms, access to resources, and other factors beyond the individual level. Structure shapes the options available to individuals, determining behavior by limiting choice. "Structural barriers" are therefore factors that limit an individual's ability to choose their behaviors based on knowledge and preference. At the same time, outcomes are not inevitable. People can change structure by exerting agency, often collectively. Viewed through this lens, the domains that constitute context according to the integrated food and nutrition system framework correspond to structure. They will therefore influence program implementation by constraining the options available to program participants, but participants may also exert individual and collective agency in order to navigate these barriers.

6.3 Methods

6.3.1 Program Description

Helen Keller International first implemented the HFP program model in three districts of Nepal in 2009. Starting in 2011 it was implemented at scale across 25 districts as part of the

USAID-funded multi-sectoral integrated nutrition program called Suaahara—a word which means “good nutrition” in Nepali. Suaahara aimed to improve the nutritional status of young children and their mothers by implementing a package of interventions that included HFP, as well as nutrition education and behavior-change, water/sanitation/hygiene (WASH), and health systems strengthening, among other components. Women who had children under the age of two, or who were pregnant at the time the program started, received agricultural inputs (seeds and chickens) and were provided with training on kitchen garden cultivation and poultry husbandry, as well as “essential nutrition and hygiene actions.” Program messages particularly emphasized the importance of implementing these actions during the, “golden thousand days,” i.e. the period of rapid cognitive and physical development between conception and a child’s second birthday.[108]

Suaahara’s multi-layered staff structure consisted of central- and regional-level teams that oversaw implementation in 25 districts. At the district level, program staff included a head district coordinator, program officers responsible for overseeing activities within specific technical areas, and 12-15 field workers who were each responsible for one or two village development committees (VDCs; Nepal’s second-smallest administrative unit). Field workers, with direction and support from district program officers, conducted the majority of all program activities in each of the communities within their VDCs. Activities included nutrition trainings, agricultural trainings, meetings with local community leaders; and home visits with program participants. Additionally, field workers and program officers provided trainings for each VDC’s cadre of female community health volunteers (FCHVs). The FCHVs in turn delivered the program messages to the women in their wards (Nepal’s smallest administrative unit) during “mothers’ group” meetings.

6.3.2 Study design

Between December 2013 and March 2014, I shadowed staff while they conducted program activities throughout Bajura. In each community visited for program activities, I also conducted interviews with mothers of young children. Participants were selected purposively to capture the perspectives of mothers from households with a range of different socioeconomic status levels and belonging to different caste groups. Program staff facilitated the selection process by indicating the households where program participants lived, and the areas of each community that were more and less advantaged. Altogether, 31 mothers participated in key informant interviews. They ranged in age from teens to early forties. Seven were Dalit (lowest status caste group), 18 were Chhetri (higher status caste group), five were Thakuri (considered higher status than Chhetris in this area), and one was Brahmin (highest status group). I conducted three focus group discussions (FGDs) with a total of 28 FCHVs (8-11 per FGD). These occurred at health posts in three different VDCs. I also conducted interviews with staff at a variety of levels within the program's management structure: three field workers, two district-level program officers, two regional-level program coordinators, and three central-level program managers.

Both the Johns Hopkins Bloomberg School of Public Health and the Nepal Health Research Council provided ethical approval for this study. Verbal informed consent was obtained prior to all interviews and FGDs. Interviews with program participants lasted an average of thirty minutes, and followed a semi-structured guide that included questions about what participants learned during program trainings, what they did with the inputs that they received, and problems they had encountered while trying to cultivate a kitchen garden or raise poultry. FGDs with FCHVs and interviews with program staff all lasted about forty-five minutes. Topics covered during FGDs included: the extent to which the women in FCHVs' mothers' groups were

implementing the nutrition and agriculture practices promoted by Suaahara, challenges they were encountering, and what suggestions the FCHVs made in response to those challenges. Many of the FCHVs were also the mothers of young children and were therefore program participants, so they also frequently talked about their own experiences with the program in response to these questions. Topics covered during staff interviews included responsibilities and day-to-day activities, the current state of various program components, and challenges encountered related to each component. In addition to interviews and FGDs, I took extensive field notes documenting the proceedings of program activities, and the appearance, rough demographics, and agricultural practices underway in each community visited.

6.3.3 Data analysis

Interview and FGD recordings were first transcribed in Nepali and then translated into English by Kathmandu-based research assistants. I then coded all transcripts and relevant field note excerpts via a two-stage process using Atlas.ti software.[109] During the first stage, I applied the broad categorical codes shown in Table 17. These were established a priori based on the study aims and the components of the integrated food and nutrition systems framework.[9] After compiling and examining coded transcript and field note excerpts by category, I identified themes within each category and applied these to the data in a second round of coding. Regrouping all data by both category and theme enabled examination of the relationships between and variation within themes. After writing a series of memos on the relationships and variations noted, I then compiled the memos by topic. Those topics correspond to each of the results sub-sections presented below.

6.4 Results

6.4.1 Participant engagement in program components

Nutrition knowledge and behavior change

Interviews and focus group discussions indicated widespread familiarity with the Suaahara program's key messages regarding maternal and child nutrition. All the mothers interviewed mentioned the importance of consuming fruits and vegetables, meat, eggs, and dairy, and feeding these foods to their young children. Their comments echoed the program's framing of nutrition as an investment in a child's future, and many referred to the association between nutrition and cognitive development. As one woman explained, "people now know that their children will become more sharp and intelligent if they eat the right food (IDI 10)." Mothers also frequently described nutrition in terms of children's academic and career success:

> *If pregnant women get a chance to rest and eat fish, meat, green vegetables, yellow fruits, and eggs their children will be wise. Later they will be able to become doctors and engineers. (IDI 11)*

According to field staff, the concept that 80% of a child's brain develops in the first two years—a statistic mentioned in nearly every training and program activity—resonated strongly in the communities where they worked and conveyed a sense of importance and urgency. Such messages had substantial emotional appeal, and many women spoke of nutrition as a way to make their children's lives better than their own had been.

Field staff and FCHVs described notable changes in maternal and child diet within the communities where they worked, particularly prioritization of the nutrition of pregnant and breastfeeding women and children, and improved complementary feeding practices. However,

when asked where such changes had not occurred, they quickly mentioned the very poor, specifically "Dalit" or "landless" households. As one FCHV said during a focus group discussion:

> *If it is difficult for them to manage rice and chapatti, how can they eat meat and fish? It's not that we're not trying, but we cannot give it to them either, so we just tell them what we have to. (FGD 2)*

Frequently the lack of change among the most marginalized was attributed in part to inadequate knowledge, awareness, or education. One field worker explained, "for both men and women of the Dalit community it is difficult to change their behavior because they are illiterate and unaware (IDI 39)," and according to one mother: "It would be better if they had an educated family member. Then they would be able to put [Suaahara's messages about nutrition] into practice (IDI 9)."

Yet, mothers from disadvantaged households also described the importance of nutrition. Their comments demonstrated their awareness of the behaviors promoted by Suaahara. They indicated that in their communities, lack of access to food, rather than a lack of awareness or education, was to blame for their inability to implement these behaviors:

> *The nutritious foods that we have here are green leafy vegetables, other vegetables, and sisnu (wild nettle). Cow ghee, buffalo ghee, milk… we have these if our economic situation is strong, but those who don't, how can they manage to eat them? That's how it is. We will eat them as much as we have them, but if not then nothing. (IDI 23)*

Another Dalit mother, when asked if she fed her children the nutritious foods that she said were discussed during program trainings, responded with frustration:

We don't have any money and even if we had money then there is no market to buy it! Anyway, if it's there in the house then we feed it, if not then we don't. If it's there in the house then we give it to the children to eat, otherwise what can we do? …We have to live with what and how much we have. (IDI 21)

Homestead Food Production

The program's agricultural components, intended to address the food access challenges highlighted above, were generally described in very positive terms by the mothers I interviewed. Most women were proud of and eager to display their gardens, and said that they found the seeds, chickens, and agricultural trainings that the program provided quite useful. However, garden size and productiveness varied dramatically, from large, well-tended plots to nearly-bare parched earth with just a few leaves sticking out, or a row of greens squeezed in along the edge of a walkway or narrow terrace. Three mothers, all very young and recently married, said that they had not planted the seeds they were given at all. The program also encouraged women to generate income by selling the produce that their families did not consume. A few mothers that lived close enough to take their vegetables to the market in the district headquarters reported earning several thousand NPR a month (1000 NPR equaled roughly ten US dollar at the time of data collection). Most mothers only reported earning a few hundred rupees occasionally by selling vegetables to neighbors, if anything.

Women spoke positively about the chickens that the program had distributed, although FCHVs estimated that only about half of the women in their mother's groups still had any poultry. The reasons varied substantially. Although in a few cases mothers and staff members mentioned religion posed a barrier for some Thakuri households, most communities were open to the idea of raising chickens, even if they had not done so previously. Few women indicated

that the chickens had been sold or consumed by their family members. However, the field worker responsible for an area where poultry had been distributed shortly before the recent election mentioned that many ended up in the bellies of local political party leaders and their supporters during campaign events. Disease also killed a substantial number of the chickens in some areas, an issue the central office was aware of and in the process of developing a vaccination program to prevent. In many households women explained that their poultry had been stolen and eaten by predators—including foxes, eagles, jungle cats, and youth from neighboring villages—or had made too much of a mess around the house and so were eventually sold, eaten, or given away. Staff members pointed out that this was why the program promoted use of coops that would both protect and contain the chickens. In fact, program rules stated that poultry should only be distributed to households that had built appropriate coops. However, few households in the communities that I visited had coops.

6.4.2 Resource access barriers and their environmental determinants

Water

Challenges related to water came up repeatedly in nearly every interview and focus group discussion. Our data collection took place during the middle of Nepal's dry season and Bajura lies in a region with a substantially drier climate overall compared to the rest of the country. Kitchen gardens therefore had to be watered several times a week during the dry season in order to thrive. For many women, however, this proved challenging or impossible:

> *They told us to eat fresh vegetables, green vegetables, carrot, yellow fruits but we don't get these foods here. Even if I try to plant these crops they don't grow as the land is dry and there are no irrigation facilities here. (IDI 17, mother)*

From February to May we face a problem until it starts raining. There is no water even to drink. We have to carry it from the source. We need water for livestock too. We have adequate land here but we don't have water. (IDI 29, mother)

Access to water differed substantially by location. For those living close to water sources, or with water distribution systems that provided adequate amounts for the community, the challenge of obtaining water was primarily a matter of finding the time required. Even if a household's water source was only a five or ten-minute walk away, the multiple trips back-and-forth to fetch enough water for a whole garden could easily take an hour, sometimes more. As one FCHV explained during a focus group discussion, "The women in our area carry water from the river 2-3 times [per week]. It takes a lot of time. For some it takes 15 minutes, but for some it takes 2-3 hours." (FGD 1)

Those living at higher elevations reported often being unable to obtain any water for their gardens. Whole communities relied on just one or two taps which delivered water from distant springs. These taps were only turned on for a few hours a day, and had to meet all of the community's water needs:

There are no irrigation facilities here so the vegetable production is decreased. Irrigation is required for good production of vegetables. There is a tap nearby for drinking water. The water is used for drinking, bathing and dishes so it cannot be used for irrigation. (IDI 27, mother)

Moreover, religious proscriptions against higher-status caste groups drinking water touched by those of Dalit caste meant that in some communities Dalit women lacked access to the community tap altogether. Staff informed me that this form of discrimination was less prevalent

than in years past, but persisted in some communities. Additionally, Dalit households were usually located farther from the community water source than higher status households.

Links between lack of water and food insecurity in Bajura went far beyond difficulty cultivating kitchen gardens. Grain could only be reliably cultivated during the dry season with irrigation, leaving those without access to irrigation highly food insecure. As one woman explained:

> *We don't have enough food because of the lack of rain. We are dependent on the rain, but it's not dependable. We have no irrigation canals. The main problem here is lack of irrigation. If there is water, there is development. (IDI 16, mother)*

Staff explained that access to water from irrigation canals, where they did exist, was complex and contentious, and usually excluded marginalized households. As one FCHV stated: "There are fights during the irrigation of paddy and wheat. There are fights even among brothers for water (FGD 3)."

Land

Lack of land also came up frequently when I asked what challenges women encountered when trying to cultivate kitchen gardens or raise poultry. Bajura's rugged topography meant that households were often densely clustered, with little open flat space near their home to build the neatly laid out vegetable beds or chicken coops shown in program training materials. Vegetables were planted in any small flat space available, or on crop terraces converted into gardens. One mother explained, "We have to build gardens far from our homes here since that is where the flat open land is (IDI 2)." Reaching these fields could take an hour or more in many

areas. Other households lacked land entirely, or owned so little that they could not afford to use even a small portion for vegetable cultivation rather than grain production. As one mother explained, “I didn’t plant the seeds I was given because we have no fields for it (IDI 7).” Similarly, an FCHV reported that among those in her mother’s group, “Most women who planted the seeds had good production, but those who don’t have land produced little (FGD 1).” Chicken coops also required substantial flat space, particularly those designed according to the program specifications. Staff explained that this was partly why so few households had constructed them. As one program officer commented, “There is a bit of a guilty feeling when we have to tell these very poor families with little land that you have to build this coop (IDI 34).”

Access to land differed substantially by caste. Many Dalit households owned no land, or very little, and relied on share-cropping, wage labor, or labor for households they had previously been bonded to through *haliya*. As one FCHV explained: “They eat only by working on other people’s land. If there is no land [of their own], then how else can they eat?” (FGD 2) Many others owned small amounts of marginal land heavily affected by erosion and landslides. Dalit mothers therefore were the most likely to cite lack of land as a reason for little vegetable production, and for overall food insecurity:

> *Food from our own fields is not enough for even 2 or 3 months. If we don’t do [wage] labor, food will only be sufficient for 2 months. If we go to India… we can work breaking stones there, then we can bring some food back from there. (IDI 23)*

Time

All of the program participants that I interviewed described an incredibly heavy workload, and many noted the difficulty of finding time to tend a kitchen garden. As one mother explained: "We have a garden, and we have everything [we need], except for free time. It's time that's lacking (IDI 1)." In particular, young women who had recently moved into their husband's household cited time as a barrier:

> *I didn't have time to plant the seeds. I was too busy… Fathers- and mothers-in-law give daughters-in-law a lot of suffering. I wash dishes, cook food, carry manure, dig fields, rear cattle, fetch fodder for cattle, bring firewood, cut grass, do other agricultural work. I have to do many tasks. I don't get enough sleep at night. My child also doesn't get enough breast milk because I don't get time to feed my baby. (IDI 17)*

Many mothers and staff described gender inequities and a traditional gendered division of labor that resulted in women receiving little support from men in the household:

> *Even if a family has five daughters and no son, they will keep on giving birth until they have a son, and meanwhile [the wife] will receive little love and support from her husband. It's like that and worse in our Bajura. The work of fetching water must be done by women. Men should not do that, that is the duty of women. Carrying heavy loads, bringing fodder from the forest, carrying manure, and carrying loads of grass are also done by women… There is a concept here that men should not help with this work. (IDI 39, field supervisor)*

As discussed previously, the distance some women had to travel to reach their garden and to collect water contributed substantially to the overall time required. As one FCHV explained, “If we could manage the time required to fetch water then it would be fine. If we had water, we would have managed the time problem (FGD 3).” Additionally, Bajura’s mountainous terrain, as well as environmental issues like deforestation and erosion, exacerbated women’s overall work burden. Several staff member noted that due to the shortages of land that many households faced, forests were constantly being cleared to create more farmland, and fire was often used to clear brush, hastening erosion. As a result, women had to travel farther and farther, often across landslide-impacted areas, to cut firewood and collect grass to feed livestock:

> *The work that takes the most time here is collecting firewood and cutting grass. It’s very far. We have to leave at six in the morning and don’t reach home until five or six in the evening. We have to work all day in the jungle, fetching grass and firewood and carrying the load back. (IDI 3, mother)*

6.4.3 Navigating barriers

Water: Using micro-irrigation equipment

The only women who did not mention water as a challenge during interviews, and who had by far the largest and most productive gardens, lived in a village about half a day’s walk from the district headquarters. Walking through this community, the lush terraces planted with vegetables stuck out immediately compared to the parched fields seen in most villages. Rather than hauling water from the river or village tap, each household had narrow, flexible pipes to deliver water to their gardens and sprinklers to distribute it efficiently.

Women informed us that the difference was due to a horticulture program implemented by CARE Nepal nearly twenty years before. Finding it lucrative to sell vegetables in the nearby district headquarters market, many families in their community continued and even expanded their production after CARE Nepal left:

> *Like Suaahara, Care Nepal used to come to our village and run training programs and meetings… Previously, we cultivated wheat and barley. But we were told that vegetables are far more beneficial. After that, we started planting vegetables on a small portion of our land. Now, we plant all over the land. We realized that it can be a source of income… We earn enough money to buy clothes for our kids and pay their fees in school. (IDI 18, mother)*

She explained that with the income they were earning they also began purchasing small-scale irrigation equipment so that production could continue during the dry season: "First, we bought one pipe for households to share. After that, we bought our own pipes and sprinklers. Now everyone has their own personal equipment for their land." Initially they had to bring this equipment all the way from the Terai, but these days, she said, it could be purchased locally for around 8,000 NPR for the lengths of pipe needed and 2,000 NPR for the sprinkler, or 10,000 NPR (about 100 USD) altogether. For most households in Bajura, spending that amount would have been unthinkable. However, this community's proximity to a major market meant that they could easily earn enough by selling their produce to justify such a large investment.

Women in many other communities also expressed a need for these items, saying that it would make garden cultivation during the dry season far more feasible and less time-consuming. They requested that the program provide them, since they could not afford the cost themselves:

I have given the Suaahara staff one recommendation which is about providing pipes and sprinklers. Maybe they can't give them to each household, but they can give one set to the community, we are poor and can't afford these things… We could use it turn by turn that way. (IDI 6, mother)

Program staff confirmed that they had been asked frequently for such equipment by the communities that they worked with. They had passed the requests on to program higher-ups but been told that this was outside the program's scope, as Suaahara was primarily intended to provide "software"—i.e. knowledge and behavior change—but not "hardware."

Land: Arranging land-sharing agreements

In one community I visited, the field worker responsible for the area explained that they had arranged an agreement with some of the village's wealthier households to share plots for kitchen gardens with women from families that owned no land. Houses were clustered closely together, particularly on the side where most of the Dalit families lived, leaving no room for garden cultivation. However, fields surrounded the town, and on one side an entire section had been divided into sub-plots for kitchen gardens. The community leader proudly pointed it out, explaining that it was one of his fields that he had "donated" for the time being as space for some Dalit mothers to plant the seeds they had received from Suaahara.

In a few other areas as well, FCHVs said that women in their mothers' groups had arranged land-sharing for group members without land:

Those who do not have land also are included in [our group]… Seeds are provided to them but they don't have land. Because of this we discussed in our

mother's group, and this group has become able to provide them with a small amount of land to cultivate the seedlings. (FGD 2)

They noted that such arrangements were not ideal: "It's not a long-term solution. They get land this way, but only if the land-owner is happy with them, otherwise no one wants to give their land to someone else (FGD 2)." However, in the short-term it enabled some women to participate in and benefit from the program who otherwise would have been excluded.

When asked why such arrangements existed in some communities but not in others, one program officer explained that it was a matter of local politics. He noted that relationships between caste-groups differed substantially between communities, and continued to be influenced by past conflict-period allegiances, and now by political party membership. He also said that the feasibility of organizing land-sharing agreements depended largely on program staff's relationships with influential local leaders.

Time: Engaging families and modeling more equitable gendered division of labor

Staff emphasized that reducing the work of mothers required engaging entire families in program activities, noting that "it is not sufficient to give trainings only to the wives (IDI 35, field worker)." Field worker- and staff-led trainings were therefore conducted, "first with mothers and the next day with mothers- and fathers-in-law and husbands (FGD 2)." During these events, staff leveraged messages regarding the link between nutrition and child brain development to urge men to support their wives more with household work, and for husbands and in-laws to prioritize women's and children's nutrition:

Mothers invest a lot as they carry the baby in their womb for 10 months, so families have to support mothers and identify nutrition problems and solve

them. The other challenge is that 80 percent of a child's brain grows in the first 24 months. So, even if there is other work we need to set aside time for the kitchen garden… Men must support women with this. (FGD 2)

When asked if it was difficult to convince family members to attend these trainings, one woman explained, "previously it was but now it isn't, men also are concerned when babies and mothers suffer." However, an FCHV noted wryly:

They come, but not always. Men prefer going to the places where they get alcohol to drink. However, we try our best to convince them. They take [the information provided] positively. They say that it's for the benefit of their own family and that programs like this bring positive changes in the community. But the most difficult task is getting them to come to the meeting. (FGD 1)

Staff also mentioned this challenge and explained some of the other ways they worked to engage men, including establishing "father's clubs," competitions for "model husband" awards, and particularly via home visits and personal interaction.

The women that I spoke with indicated that changes in gender norms regarding work division were occurring, slowly. They attributed this to both the "awareness raising" of Suaahara and other programs, and to improvements in education levels more broadly. Nearly everyone stated that gender norms had improved compared to the past, but were still far from equitable:

In the past men didn't collect firewood or carry manure. They didn't work along with women, but now some work along with women and eat along with women… But some uneducated fools say that, 'he now belongs to his wife. He

obeys what his wife says.' That is why the men who help with work also suffer. Their confidence is decreased. (IDI 3)

As this quote suggests, men also dealt with public pressure to conform to gender norms, possibly facing ridicule if they assisted with tasks viewed as "women's work." For this reason, staff and FCHVs spoke frequently of the need for role-modeling, explaining that their households and those of other influential community members should demonstrate the behaviors the program promoted in order to increase social acceptability:

It is very difficult… it is not easy to bring change overnight. There are different kinds of people, they have different perceptions. We have to implement it ourselves and create an example. And they will follow. (FGD 1)

Similarly, when asked how changes in gender norms could be brought about in her community, a field worker suggested organizing "excursions" that would allow people in one community to learn from those in another:

"For example, Jung Bahadur was the Rana Prime Minister. He established an English school after he visited Britain… He went there, saw [their schools] and after returning to Kathmandu he established Darbar High School in Rani Pokhari. Like that, people can go to other places, observe things, and think maybe they can do it too."

In some cases, however, encouraging men to support their wives by helping with household work was not an option. Among highly food insecure Dalit communities, men often migrated seasonally to work as laborers in India so that they could purchase the rice that their households relied on for survival. As one woman explained when asked if her husband helped

her with work related to her garden: “But where is my husband? He has gone to India to work breaking stones and carrying heavy loads to support us (IDI 21).”

6.5 Discussion

Our findings demonstrate the pivotal role that contextual factors play in determining the potential for a nutrition-sensitive agriculture program to serve its intended beneficiaries. The program participants that we interviewed demonstrated high levels of knowledge about the program’s nutrition messages and expressed interest in and motivation to engage in the homestead food production practices promoted. Yet for some mothers, particularly the youngest and the most marginalized due to caste and geography, lack of access to resources meant they derived little or no benefit from the program’s agricultural components. Three resource-access barriers came up repeatedly: lack of water, lack of land, and lack of time. Factors within the biophysical and sociocultural environments, as well as historic and current land and labor policies, interacted to influence access to these crucial resources, and to determine the viability of strategies to improve access. Caste group and gender norms emerged as particularly influential sociocultural factors, while climate, terrain, and irrigation infrastructure emerged as particularly influential biophysical factors.

Many studies have documented the potential for homestead food production and other nutrition-sensitive agriculture programs to improve household access to nutritious foods.[7, 14, 59, 103, 110] Indeed, our findings indicated that many women benefitted substantially from their engagement in Suaahara program activities. However, as Dury et al. point out, it is important to consider who does not benefit from agricultural development interventions.[111] They note the risk of worsening inequalities through exclusion of “the most socially and politically fragile (p. 90).” They also caution against interventions that may increase women’s work burdens, a

concern discussed in several recent reviews of nutrition-sensitive agriculture interventions.[17, 96, 112] Our findings make a valuable contribution to the existing literature on these topics by describing the context-specific resources and environmental factors that produce exclusion and determine program impacts on women's work burdens. Moreover, they demonstrate how structural factors interact to produce differing levels of exclusion.

Limitations of this study include the lack of representation of indigenous groups among the study participants. Although they make up a relatively small portion of Bajura's population, they would likely have been able to describe unique experiences and challenges encountered with the program, as many of the indigenous groups in Bajura migrate seasonally. Additionally, I did not ask the women that I interviewed about their socioeconomic status—specifically the amount of land that their household owned, or whether they were engaged in wage or other types of labor. Many women volunteered information about their household's land or labor activities in the course of the interview. However, without comparable data from all of the study participants, it is hard to tell whether we succeeded in accessing the perspectives of women across the full range of Bajura's socioeconomic spectrum. Despite these limitations, the study's findings have important implications for program planners.

6.6 Implications

Use of micro-irrigation equipment emerged as a potential strategy for addressing both water and time-related constraints to kitchen garden cultivation. The case of the community that had already invested in such equipment also provides an interesting example of the potential for long-term sustainability of agricultural interventions, under the right conditions. In that community's case, proximity to a major market was a critical facilitator of the program's sustainability, and of the community's ability to generate enough income to invest in micro-

irrigation. Most communities in Bajura lack the market access needed to earn substantial amounts of income from home garden production, making the cost of micro-irrigation equipment prohibitive. Enabling households to access such equipment, possibly by subsidizing it or through community sharing schemes, could ease access to water and substantially reduce the work burden associated with kitchen garden cultivation for many participants.[113-115]

More broadly however, infrastructural investments in water distribution systems and field crop irrigation are a critical basic need throughout Bajura. Since the time of data collection, a multi-year drought has exacerbated food insecurity in the district.[116, 117] Recent news articles document massive crop failure, increased malnutrition, a spike in labor migration, and women waiting in line for hours for one bucket of water.[116, 118-120] With droughts likely to become increasingly common as climate change accelerates,[121] crop irrigation and drinking water facilities will only become more essential for survival.

Study participants also mentioned sharing of land by wealthier households as a strategy for enabling program participation among landless households, although they indicated that the feasibility of such arrangements depended on community dynamics between caste groups. This suggests that program planners should consider allocating funds for renting communal space that women from landless households can use to establish gardens. This would increase their ability to engage in the program, without making them reliant on the goodwill of land-owners.

Addressing the underlying issue of landlessness will require land reform. Numerous experts make strong cases regarding the need for land reform in Nepal.[100, 122] A recent study by Paudel and Saito indicates that enforcement of land reform policies that the Nepali government has committed to previously but never enacted could both reduce inequality and increase productivity across all sectors of Nepal's economy.[123] Yet, although it has been on the political

agenda for years, little progress has been made towards enacting land reform due to the vested interest of political elites maintaining the status quo.[122] Adhikari notes that "successful land reform should be led by grassroots political movements, with limited external intervention (p.17)." He asserts that the role of civil society and external agencies is to create an enabling environment for those at the grassroots level to pursue their own land reform agenda. Specifically, he suggests advocating for government provision of minimum wages and insurance for landless laborers. Similarly, Pain calls for the Nepali government and donor organizations to make a wider commitment to "more robust and widespread social protection measures."[100]

Finally, engaging whole families and encouraging men to provide greater support with household work via role-modeling emerged as strategies that staff and FCHVs used to address women's lack of time for program engagement. Inviting husbands and parents-in-law to trainings is already a component of Suaahara's program design. However, our findings suggested that ensuring their attendance could be difficult, and therefore indicated the importance of field workers being persistent and using a variety of strategies to engage men. The emphasis on using role-modeling by community leaders and visits to other communities as a way to change gender norms echoes Bandura's social learning theory.[124] It highlights the importance of staff and FCHVs serving as role models. This suggests that programs need to consider not only the technical training of frontline staff, but also make sure that they and their families are capable of modeling the more equitable behaviors promoted. It also suggests the important role of female field workers, women who have obtained paid employment thanks to their education, as examples of the benefits of educating girls.

Study participants' comments, and my own observations, indicated that in many areas changes in gender norms regarding work division were beginning to change, slowly. Yet, as

Cameron asserts in her work on divisions of labor in far-western Nepal, examining gender without also examining the influence of caste can obscure important differences.[125] As our findings showed, Dalit women whose husbands must work in India to meet their household's food needs are responsible for all household work, regardless of gender norms. The need to migrate stems from lack of sufficient cultivable land, and lack of local employment opportunities. Again, addressing these structural barriers will require land reform and establishment of social protection mechanisms.

6.7 Conclusion

In far-western Nepal, levels of access to key resources—water, land, and time—determine women's abilities to engage in and benefit from nutrition-sensitive agriculture programs. Access to these resources depends upon a complex constellation of sociocultural and biophysical environmental factors, as well as historic land and labor policies. Program participants and field staff find various ways to navigate structural barriers. These, too, are inevitably context-dependent. However, the examples point towards strategies that could be implemented more widely. These include: providing or subsidizing micro-irrigation equipment; renting communal fields where women from landless households can establish gardens; and finding ways to support staff, FCHVs, and their families in role-modeling more equitable gendered divisions of labor. Our findings also indicate areas where structural change is most needed. Long-term solutions to the barriers that prevent the most marginalized households in far-western Nepal from benefitting from nutrition-sensitive agriculture programs are complex. They will likely require investment in irrigation infrastructure, equitable land reform, and establishment of robust social protection measures.

6.8 Tables for Chapter 6

Table 17. Coding framework used for analysis of qualitative data (back to text)

A Priori Categories	Emergent Themes
Participant Engagement in and Benefits from Program	Knowledge of Nutrition Messages Motivation to Implement Program-Promoted Behaviors Barriers to Implementing Behaviors Engagement in Kitchen Garden Cultivation Barriers to Kitchen Garden Cultivation Engagement in Poultry Raising Barriers to Poultry Raising
Resource Access	Water Land Time
Biophysical Environment	Climate Season Irrigation Facilities Terrain Elevation Deforestation & Erosion Proximity to Market
Sociocultural Environment	Caste Group Gender Norms Household Work Allocation Labor Migration
Policies & Institutions	Historic Labor & Land Ownership Systems Activities of other NGOs Political Factions
Barrier Navigation Strategies	Micro-Irrigation Land-Sharing Agreements Engaging Family Members Role-Modeling More Equitable Gender Norms

Chapter 7. Conclusions

7.1 Synthesis of Results

Results from manuscript one demonstrate the influence of both season and region on child diet quality. They also show how in some cases the extent of variation by season depends upon caste or household wealth. Manuscript one analyses did not explore the reasons for the observed associations, however findings from the other two manuscripts suggest some possible explanations. For example, reduced consumption of vitamin A-rich fruits and vegetables and dairy during the winter in the mountains is likely due to the more pronounced dry season in that region, combined with a lack of irrigation facilities. This may impede household production of fruits and vegetables, and reduce the availability of fodder for cattle. The greater reduction in fruit and vegetable consumption during the winter among poorer households is likely due to a combination of them having less access to water for production, and less ability to purchase foods when their own production is inadequate. Similarly, the greater reduction in dairy consumption during the winter among Dalit households may be due to their reliance on more marginal land for fodder that is quickly depleted during the dry season. Further research would be needed to determine the accuracy of these particular hypotheses, but these examples demonstrate the overall point: the extent to which households are impacted by or resilient to biophysical factors, like season, depends largely upon sociocultural factors. Moreover, these examples demonstrate potential vulnerabilities to climate change. In the hills and mountains of Nepal, droughts are expected to increase in length and severity as global temperatures rise.[121] Therefore, the changes in consumption that occur during the dry season in the mountains, and the households in which these changes are most pronounced, are likely to be amplified as a result of climate change.

Results from manuscript two indicate the mechanisms through which contextual factors influence child diet quality. Season, region, and resource access factors influenced likelihood of a household producing or purchasing nutritious foods, and as household production or expenditure increased, children's consumption of nutritious foods did as well. Land ownership was the primary resource access factor that influenced production, and wealth was the primary resource access factor that influenced expenditure. Proximity to water source also influenced production of fruits and vegetables. As a whole, these results suggest that household access via production and purchasing mediates the effects of access to resources (such as wealth and land) and of season and region on children's nutritious food consumption. Again, this is a hypothesis that would be interesting to test further. Notably, manuscript two results also indicate that strategies like increasing household fruit and vegetable cultivation and promoting poultry raising are likely to improve children's diet quality—thereby supporting the premises underlying the HFP program examined in manuscript three. They also suggest that the extent to which households are able to engage in such strategies may be influenced by resource access and biophysical factors.

Results from manuscript three provide a situated understanding of how factors in the biophysical and sociocultural environment influence one another and subsequently determine an agricultural intervention's capacity to reach vulnerable households. They reinforce several of the factors identified in manuscript two—particularly land and water—and identify others, like time, that were not explored in the previous analyses. These results also indicate strategies that programs could employ to enhance their effectiveness, as well as limits to program effectiveness within the constraints of broad structural barriers. Manuscript three findings highlight the necessity of key structural changes for improving diet quality among Nepal's most vulnerable children, as well as addressing root causes of food insecurity more broadly.

Finally, results from manuscripts two and three, when taken together, also demonstrate why it is problematic to frame the problem of poor nutritional behaviors as largely an issue of lack of knowledge and education. Allowing these to prevail as primary explanations for poor health and nutrition can obscure recognition of the structural barriers that need to be addressed and may lead to victim-blaming.[126, 127] This is not to say that knowledge and education are not important. They are vital, and maternal educational attainment in particular has been shown to be an important determinant of child nutrition status.[8, 98] However, emphasizing these factors, without also focusing on structural barriers, effectively places the burden of responsibility for change on the most marginalized. It shifts attention away from those who benefit from the inequitable distribution of resources. The situation is complex in Nepal, where even those households who control the most power and resources locally may still be deeply impoverished and food insecure. However, equitable program implementation requires recognition of these complexities.[17, 111]

7.2 Program and Policy Implications

These dissertation results have numerous implications for the designers and implementers of interventions that aim to improve household food access and child diet quality. First is the need to be watchful for seasonal vulnerability to decreased consumption of nutritious foods, and to be cognizant of the fact that seasonal effects will vary across regions and will affect certain population groups more than others. Strategies for addressing seasonal vulnerabilities will vary substantially depending on context, but may include providing communities with micro-irrigation equipment so that households can cultivate fruits and vegetables even during the dry season, or introducing more drought tolerant varieties of cattle fodder.[128, 129] For food security and livelihoods more broadly, and for climate change adaptation

capacity, substantial investments in irrigation infrastructure are a necessity in many areas of Nepal.[130-132]

This dissertation also sheds light on the issue of women's work burdens and the question of whether nutrition-sensitive agriculture programs unduly exacerbate this burden. In short, the findings indicate that it depends. The time requirements for a woman's participation in an HFP program depend upon the season, proximity to a water source, distance between her home and flat space where a garden can be cultivated, extent to which other household members support her with the work, and whether her husband and other household members have migrated for work. Findings suggest that in many cases provision of micro-irrigation equipment could ease the time burden involved in carrying water, and encouraging husbands and other family members to support women with household work could reduce women's overall work burdens. However, these solutions are moot in situations where a household owns no land, where water is extremely limited, or where labor migration leaves women with little potential support.

This points towards another overarching implication of this research—the need to identify those who are excluded from program participation and what the mechanisms of exclusion are. As noted previously, access to water and time availability play roles in determining a program participant's ability to engage in program activities. The other major factor is land. The pivotal role of land ownership in determining who benefits from nutrition-sensitive agriculture programs and who is excluded emerged in my dissertation findings and is echoed in two recent reviews of agricultural interventions by Dury et. al. and Fiorella et. al.[17, 111] As Fiorella notes, "landless food producers are often among the most food insecure and are entirely omitted from this class of interventions (p.45)."

In Nepal, land is the currency through which historic caste- and ethnicity-based inequities and exploitative agricultural labor systems are reproduced.[64, 100] Land reform has been an important political topic in Nepal for years. It was a key demand of the Maoist insurgency in the 1990's. Yet even after the civil war ended in 2008 and the Maoist party led the government, land reform recommendations made by high level commissions were never enacted due to lack of political support from government elites.[133] Many activists now call for prioritizing it on the legislative agenda.[100, 122] As Sharma et. al. argue, "any goal of increasing agricultural productivity and workers' incomes cannot be achieved without considering the diverse contexts associated with land issues in Nepal (p.529)."[133] Indeed, from a global perspective, Lipton and Saghai describe land reform as a powerful (and ethically justifiable) mechanism for improving food and nutrition security in low-income countries. Additionally, a study of India's extensive land reform efforts since the 1950's indicates that they led to significant improvements in health and nutritional status. The authors estimated that land reform was associated with an increase in height of 3.3-4.5 centimeters among women living in areas where reforms were implemented while they were children.[134]

As Burchi et. al. assert, "it is much easier to design an intervention that looks separately at three core sectors like agriculture, health and nutrition, and does not tackle complex problems that involve land, gender, trade and markets, among others (p.368)." Yet as the findings from this dissertation show, tackling these complex problems is necessary if nutrition programs are to improve diet quality among the most vulnerable. This is not to say that the international non-governmental organizations and bilateral funders driving most programs need to drive these changes as well. In fact, as Adhikari notes, demands for social reforms like land redistribution may be best done at the grassroots level.[122] However, such issues should be on the radar of

implementing agencies and donors and should be part of the conversation about nutrition in Nepal.

Finally, Nepal's upcoming local elections—the first in 20 years—signify a powerful new opportunity for rural Nepalis to hold their leaders accountable for bringing about structural change. They have the potential to expand village- and district-level access to substantial government resources which are currently allocated but rarely spent due to lack of local finance transfer and administration capacity.[135] Such funds could prove transformative for development of irrigation and other infrastructure, for the creation of social protection mechanisms, and for local employment opportunities. Substantial uncertainty remains regarding whether elections will even take place as planned, the extent to which power will truly be decentralized, and what the governance capacity at local levels will be. [135, 136] However, a shift towards local political control will undoubtedly change the Nepali context, opening new possibilities for enhancing livelihoods, food security and diet quality.

Appendices

Appendix 1. Topics covered in semi-structured interview guides for interviews with mothers and focus group discussions with FCHVs (back to text)

Topics covered in semi-structured interviews with mothers:

- Garden location, size, condition
    - Crops currently grown in garden and grown at other times of year
    - When the garden was started
- Challenges growing crops
    - Weather
    - Water sources
    - Daily work schedule, including work in garden, and roles of family members
- Amounts of crops produced and how they are used
    - Whether crops are kept for household use or sold and how those decisions are made
    - Where crops are sold, income earned, how income is used
    - How crops kept are prepared and who eats them
- How seeds and other garden inputs are obtained
    - Inputs received from the HKI/Suaahara HFP program and how they have been used
    - Other sources of inputs and their costs
    - Additional inputs needed
- Poultry husbandry
    - Whether household received poultry
    - Whether household has coop for chickens
    - Whether coop is used
- Challenges raising poultry
    - Reasons why household no longer has poultry
    - Challenges constructing coops
- Egg and meat production from poultry and how they are used
    - Whether eggs are kept for household use or sold and how those decisions are made
    - Who consumed eggs and chicken meat within the household
- Sources of information regarding growing garden crops & poultry husbandry
    - Program trainings and information learned
    - Information learned from agricultural extension workers and HFP village model farmers
    - Additional sources of information
- Experiences with other program activities
    - Activities and trainings attended

- Participation in mothers groups
- Contacts with and information learned from field workers and FCHVs
- Additional information and resources needed

Topics covered in focus-group discussions with FCHVs:

- Role with program and training received
- Responsibilities and activities
- Challenges faced when performing responsibilities
- Trainings and advice given to mothers
- Seeds and other inputs provided to mothers
- Challenges mothers face when cultivating home gardens or raising poultry
- Changes in food production observed over the course of the program

Appendix 2. Reasons for children's missing panels of data in PoSHAN sentinel site data set (back to text)

	P1	S1	S2	P2	S3	S4
Total Children[a]	626	571	490	767[b]	708	628
	N (% of previous round N)					
Total missing since previous round	N/A	66 (10.5%)	103 (18%)	39 (8%)	73 (9.5%)	103 (14.5%)
Died	N/A	0 (0%)	0 (0%)	0 (0%)	1 (0.1%)	0 (0%)
Ineligible due to age[c]	N/A	28 (4.5%)	67 (11.7%)	0 (0%)	26 (3.4%)	57 (8.1%)
Household moved or migrated	N/A	3 (0.5%)	15 (2.6%)	25 (5.1%)	4 (0.5%)	5 (0.7%)
Not met until end of survey	N/A	34 (5.4%)	20 (3.5%)	14 (2.9%)	36 (4.7%)	41 (5.8%)
Refused interview	N/A	1 (0.2%)	1 (0.2%)	0 (0%)	2 (0.3%)	0 (0%)
Unknown	N/A	0 (0%)	0 (0%)	0 (0%)	4 (0.5%)	0 (0%)

[a] Children were also added in each round due to births and to children missing in the immediately previous panel participating again, therefore the sum of the total and the total missing for each round is greater than the previous round total

[b] Sample increased substantially because those children that were born (N=74), moved into a study household (N=6), or whose household moved into the study area (N=133) since P1 were added

[c] During P1, S1, and S2 only children under 59 months were included; during P2, S2, and S3 children under 72 months were included; some children excluded due to their age initially were later included again after age criteria changed

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Curriculum Vitae

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EDUCATION

PhD in International Health **Expected May 2017**
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
2014-2017 Center for a Livable Future (CLF)—Lerner Fellow
2015-2016 Borlaug Fellow in Global Food Security

Masters of Science in Public Health (MSPH) in International Health **May 2013**
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD
Concentration: Social and Behavioral Interventions
Delta Omega Alpha Honors Society Inductee
2012 Johns Snow International Health Department Award

Bachelor of Arts in Anthropology and Biology & Society **May 2008**
Cornell University, College of Arts and Sciences, Ithaca, NY

INTERNATIONAL RESEARCH EXPERIENCE

Dissertation Research, Policy & Science for Health, Agriculture & Nutrition (PoSHAN) Study
February 2016 – Present
Nepal Nutrition Innovation Lab (Johns Hopkins & Tufts University), Kathmandu, Nepal & Baltimore, MD

Research Assistant, Modeling Climate Change Impacts on Food Systems in East Africa
November 2015 – December 2016
Johns Hopkins CLF & Department of Environmental Health and Engineering, Baltimore, MD

Fulbright Scholar, Homestead Food Production Program Implementation in Western Nepal
August 2013 – June 2014
Helen Keller International, Kathmandu, Nepal & Bajura, Nepal

Intern/Research Assistant, Suaahara Social and Behavior Change Communication
June 2012 – August 2013
Johns Hopkins Center for Communication Programs & Save the Children, Kathmandu, Nepal & Baltimore, MD

DOMESTIC RESEARCH EXPERIENCE

Research Assistant, Industrial Food Animal Production Atlas
December 2014 – May 2015
Johns Hopkins CLF Mapping Team, Baltimore, MD

MSPH Student Researcher, Engaging Youth in Sustainable Agriculture and Nutrition
February 2012 – May 2013
Real Food Farm (RFF) Education Program, Baltimore, MD

Project Coordinator, Evaluation of Baltimore Outward Bound's Youth Programs
August 2011 – May 2013
Johns Hopkins School of Public Health Social and Behavioral Intervention Program, Baltimore, MD

RESEARCH CONSULTING EXPERIENCE

Analyst & Technical Writer, World Health Organization (WHO) Reports & Publications
Periodically May 2015 – Present
WHO Department of Reproductive Health and Research, Geneva, Switzerland

Qualitative Data Analyst, Investigation of 'AIDS Competent' Schools in Rural Zimbabwe
June – October 2014
London School of Economics Department of Social Psychology, London, England

Quantitative Data Analyst, Nepal Health Communication Capacity Collaborative (HC3)
April – November 2014
Johns Hopkins Center for Communication Programs, Kathmandu, Nepal

TEACHING EXPERIENCE

Co-Instructor, Team-Based Qualitative Data Analysis Training
April 2016
Johns Hopkins Center for Communication Programs & Marie Stopes International, Kathmandu, Nepal

Teaching Assistant, Introduction to Formative Research
March-May 2015
International Health Department, Johns Hopkins Bloomberg School of Public Health

Teaching Assistant, Qualitative Research Theory & Methods/Qualitative Data Analysis
February-May 2015
International Health Department, Johns Hopkins Bloomberg School of Public Health

Instructor, Outward Bound USA
June 2009 – August 2011
Baltimore Chesapeake Bay Outward Bound School & Voyageur Outward Bound, Baltimore, MD & Ely, MN

PEER REVIEWED PUBLICATIONS

Underwood, C., Broaddus, E., Kc, S., Thapa, K. (2017). Community theater participation and nutrition-related practices: Evidence from Nepal. *Journal of Health Communication*, 1-10

Caldas, S., Turkel, R., Nelson, A., Pandey, S., Wu, Y., Broaddus, E., Beebe, M., Rivera, G., Winch, P. (2017). 'All of that's gone now': The failure to sustain police-youth programmes in Baltimore City. *The Police Journal: Theory, Practice and Principles.*

Caldas, S., Broaddus, E., Winch, P. (2016). Measuring conflict management, emotional self-efficacy, and problem solving confidence in an evaluation of outdoor programs for inner-city youth in Baltimore, Maryland. *Evaluation and Program Planning*, 57, 64-71.

Broaddus, E., Przygocki, L., Winch, P. (2015). Engaging city youth in urban agriculture: examining a farm-based high school internship program through the lens of Self-Determination Theory. *Children, Youth and Environments*, 25(3), 22-39.

Muzyamba, C., Broaddus, E., Campbell, C. (2015). "You cannot eat rights": a qualitative study of views by Zambian HIV-vulnerable women, youth and MSM on human rights as public health tools. *BMC International Health and Human Rights*, 15(1).

Coultas, C., Broaddus, E., Campbell, C., Andersen, L., Mutsikiwa, A., Madanhire, C., Nyamukapa, C., Gregson, S. (2015). Implications of teacher life-work histories for conceptualisations of 'care': narratives from rural Zimbabwe. *Journal of Community and Applied Social Psychology*, 26, 323-339

Surkan, P., Broaddus, E., Shrestha, A., Thapa, L. (2013) "Non-disclosure of widowhood in Nepal: implications for women and their children." *Global Public Health* (ahead-of-print), 1-12.

Lam, Y., Broaddus, E., Surkan, P. (2013). "Literacy and healthcare-seeking among women with low educational attainment: analysis of cross-sectional data from the 2011 Nepal Demographic and Health Survey." *International Journal of Equity in Health*, 95(12), 1-12.

Broaddus, E., Scott, K., Gonsalves, L., Parrish, C., Rhodes, E., Donovan, S., Winch, P. (2013). Building connections between officers and Baltimore City youth: key components of a police-youth teambuilding program. *Journal of Juvenile Justice*, 3(2), 48-60.

REPORTS & GREY LITERATURE PUBLICATIONS

Trends in maternal mortality: 1990 to 2015 (2015). *WHO, UNICEF, UNFPA, World Bank Group, UNPD.* Available here.

Nepal Earthquakes 2015: Desk review of existing information with relevance to mental health & psychosocial support (2015). *IASC Reference Group for Mental Health and Psychosocial Support in Emergency Settings.* Available here

The H+ partnership: joint country support to improve women's and children's health—2014 Progress Report (2015). *WHO, UNICEF, UNFPA, UNAIDS, World Bank Group.* Available here.

Conceptualising schools as a source of social capital for HIV affected children in southern Africa (2014). *The London School of Economics and Political Science.* Available here.

Community Theater Effects on Nutrition-related Outcomes in Nepal: Evidence from a pre-test/post-test with random assignment to intervention groups and matched comparison groups (2013). *Johns Hopkins Bloomberg School of Public Health/Center for Communication Programs.*

Household-focused understanding of behavioral and cultural practices to improve infant and child health and nutrition outcomes in Nepal: a formative research assessment (2013). *Research Inputs and Development Action—Nepal, and the Johns Hopkins University Center for Communication Programs*.

Community Risk Factors for Mortality and Exposure to Environmental Hazards in the San Joaquin Valley. (2012) *Center on Human Needs, Virginia Commonwealth University.* Available here.

Presumptive Eligibility for Pregnant Women (2008). *State Health Policy Monitor.* Available here.

PRESENTATIONS

Growing on the margins: A case study examining implementation of a nutrition-sensitive agriculture program in far-Western Nepal (roundtable presentation). *American Public Health Association Annual Meeting: Student Project Session*. Denver, CO. October 1st, 2016.

Promoting vegetable cultivation among landless households in Far-Western Nepal. *South and Central Asia Fulbright Conference*. Chennai, India. March 14th, 2014.

Engaging Urban Youth in Sustainable Agriculture: A case study of the Real Food Farm internship program (poster presentation). *American Public Health Association Annual Meeting: Nutrition Student Research Session.* Boston, MA. November 11th, 2013.

Community perspectives on the role of education in maternal and child nutrition: findings from the formative research for an integrated nutrition program in Nepal (poster presentation). *Second Annual Nutrition Innovation Lab Symposium*. Kathmandu, Nepal. August 13th, 2013.

Food security strategies for landless marginalized households in Nepal. *Borlaug Summer Institute on Global Food Security*. Lafayette, IN. June 7th, 2013. Group Award for Best Presentation.

Partnering with Outward Bound to evaluate programs for urban youth (poster presentation). *Social Determinants of Health Symposium. Johns Hopkins University Urban Health Institute.* Baltimore, MD. April 24th, 2013.

Current trends affecting child feeding and care in rural Nepal: results from the formative research for an integrated child nutrition intervention (poster presentation). *Future of Food and Nutrition Conference. Tufts University Friedman School of Food Science and Policy.* Boston, MA. April 6th, 2013.