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Esther M. Choo

Improving Nutrition in Nepal: An analysis of food environments, behavioral determinants of consumption, and costs of a multisectoral nutrition program

Esther M. Choo

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Reading Committee:

Carol Levin, Chair

Christine McGrath

Arianna Rubin Means

Program Authorized to Offer Degree:

Global Health

University of Washington

Abstract

Improving Nutrition in Nepal: An analysis of food environments, behavioral determinants of consumption, and costs of a multisectoral nutrition program

Esther M. Choo

Chair of the Supervisory Committee:
Carol Levin
Department of Global Health

Despite significant gains to achieve national nutrition targets in Nepal, infant and young child feeding practices remain sub-optimal.[1] Increased consumption of processed foods high in sugar, salt, and fat in conjunction with low dietary diversity and micronutrient deficiency lead to poor overall diets and nutritional outcomes.[2–4] Understanding external and personal drivers of infant and young child feeding practices are a key step to design behavior change strategies that improve child nutrition outcomes. Economic evaluations of multi-sectoral nutrition programs aimed to improve child diets can also be used to inform program design and decision making for budgeting and resource allocation. The objective of this dissertation was to identify food environment and behavioral determinants of infant and young child feeding behaviors and costs of a scaled-up program focused on improving child nutrition outcomes.

The first study used data collected from households in a cross-sectional survey representative of 42 districts in Nepal. We assessed associations between food environments and child dietary consumption using a novel scale to measure perceived food environments. Vegetable food environments were significantly associated with reaching minimum dietary diversity, while processed snack food environments were associated with unhealthy diets and consumption. Food safety, year-round access, and accessibility of vegetables as well as marketing, availability, convenience, and food safety of processed foods influenced these relationships. Living in a food oasis was protective against unhealthy diets and consumption while living in a food desert or food swamp was associated with unhealthier diets.

The second study employed the Theoretical Domains Framework to identify behavioral determinants of key infant and young child feeding practices using data from four years of cross-sectional monitoring surveys in Nepal from the *Suaahara* II program. We observed that responsive feeding skills, knowledge of timely introduction of complementary foods, and active participation in community health groups were associated with child dietary diversity. Meeting with female community health volunteers modified the relationship between feeding skills and diet diversity.

The third study applied a mixed methods approach combining financial and economic costs to estimate total incremental and unit costs of the *Suaahara* II scaled up multisectoral nutrition program. In addition, we estimated time use of volunteers and participants in community-based nutrition programs. We demonstrate that costs of scaled up programs can be substantial especially when considering contributions made by volunteers and program partners. Community health and agriculture extension volunteers contributed significant time to the program.

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DEDICATION

For Kevin, Joshua, and Olivia

Chapter 1. Introduction

While strides have been made in reducing undernutrition over the past two decades, persistent stunting still affects more than one third of children, and the prevalence of overweight among children has increased dramatically in the last two decades in Nepal.[5,6] Diet quality is an immediate determinant of both overweight and underweight. Understanding determinants of diet quality is critical to design targeted interventions to tackle the rise in consumption of ultra-processed, nutrient-poor foods and improving diet diversity and nutrient adequacy. Both external and personal factors play a major role in food acquisition and consumption. Food environment factors such as availability, marketing, accessibility of foods as well as behavioral factors including responsive feeding skills, knowledge, and participation in health support groups can have an important impact on dietary outcomes for children. Identifying key determinants of child dietary consumption in Nepal can inform interventions designed to reduce malnutrition in all its forms.

The government of Nepal and Helen Keller International implemented a large scaled multisectoral nutrition program, *Suaahara* II (SII) to promote key infant and young child feeding, such as optimal breastfeeding, and appropriate complementary feeding to reach over 900,000 households in 42 districts in Nepal.[7–9] SII supported female community health volunteers (FCHVs) to provide counseling to pregnant women and mothers with children under two years of age to improve critical nutrition practices during the first 1000 days post conception. To further inform community interventions designed to change behaviors, assessing costs can help policy makers assess value and affordability of programs as they aim to reach their national nutrition targets. Currently there is limited evidence of the costs of large scale

multisectoral nutrition strategies especially the additive costs resulting from the integration of activities across sectors. In addition, little is known about the opportunity costs of time for volunteers and program participants to take part in community level activities.

To inform behavior change interventions and community activities of multi-sectoral nutrition programs, this dissertation assesses the food environment and behavioral factors associated with child dietary consumption in Nepal and the cost of implementing a scaled-up multi-sectoral nutrition program in Nepal to improve infant and young child nutrition behaviors. The first study presents an analysis of associations between food environments and child dietary consumption using a novel scale to measure perceived food environments. The second study identifies behavioral determinants of key infant and young child feeding practices using an implementation science framework. The third study estimates costs and volunteer and participant time use of a multi-sectoral nutrition program using a standardized costing approach.

Chapter 2. Food environment determinants of dietary consumption among children

2.1 Abstract

Introduction: Significant shifts in food systems and environments in the last two decades have resulted in a nutrition transition marked by increased consumption of unhealthy foods resulting in the rise of diet-related disease in Nepal and most low- and middle-income countries (LMICs). In LMICs, food environments are complex as individuals access food from a wide variety of sources including informal markets, food stalls, agricultural activities, bartering, in addition to formal markets. New methods to measure the effect of food environments on healthy and unhealthy food consumption are needed.

Methods: We developed a novel food environment tool to capture perceived external domains of availability, stability, vendor/product properties, marketing, and personal domains of accessibility, convenience, affordability, social forces, and desirability of processed foods and dark green leafy vegetables. We followed a seven-step process to develop and validate the food environment rapid assessment (FERA) tool including assessing face, content, and criterion validity, pilot testing the tool, and integrating it into a household survey. We used the FERA to test associations between food environments and healthy and unhealthy food consumption using Poisson mixed effects models with robust standard errors. We assessed overall food environments by dimension and type.

Results: Piloting of the tool (n=146) resulted in a parsimonious set of questions that can easily be incorporated into existing household surveys. We adjusted the tool to include questions for both rural and urban consumers, and response options to reflect the local context for improved

comprehension. The FERA was also found to be face, content and criterion valid. Processed snack food environments were associated with unhealthy consumption (adjusted Prevalence Ratio [aPR]: 1.05, 95% confidence interval [CI]: 1.02-1.08) and unhealthy diets (aPR: 1.14, 95% CI: 1.07-1.23), while dark green leafy vegetable food environments were associated with healthy consumption (aPR: 1.04, 95% CI: 1.01-1.06). Food safety, year-round access, and accessibility of vegetables as well as marketing, availability, convenience, and food safety of processed foods in particular were associated with consumption outcomes. Living in a food swamp area was associated with a 21% reduction in the likelihood of achieving minimum dietary diversity (MDD) (p=0.008) and living in a food desert was associated with a 54% increased risk of zero fruit and vegetable consumption (p=0.011).

Conclusion: The FERA can be readily adapted and inserted into a household monitoring survey to measure the influence of food environments on food consumption patterns. Food environments significantly shape diets among children emphasizing the urgency to implement policy and behavioral interventions that foster healthier diets to tackle the double burden of malnutrition in Nepal.

2.2 INTRODUCTION

In the last several decades, increases in income and globalization have contributed to significant shifts in foods systems, with increased availability of food choices from local and commercial sources, formal and informal markets, fast food kiosks and restaurants, associated with increased consumption of unhealthy foods. Increased access and consumption of ultra-processed foods have resulted in rapid rises in the prevalence of obesity, overweight, and diet-related noncommunicable diseases across low- and middle-income countries (LMIC).[10,11] These shifting food systems have had wide public health implications. Globally each year, unhealthy diets cause an estimated 11 million deaths with consumption of ultra-processed foods causing over 3 million deaths.[12,13] In Nepal, overweight among children has risen substantially, with approximately one-fifth of girls and boys experiencing overweight and 69% of children consuming processed foods high in sugar, salt, and unhealthy fats.[1,14] Identifying factors related to the increased consumption of unhealthy foods in Nepal is critical for policy makers to curb non-communicable diseases through policy and adoption of healthier overall diets.

Applying a food environment lens takes into consideration how an evolving food system shapes consumption patterns in rural and urban, and poor and wealthy households. Food environments are where consumers interface with the food system through market and non-market based food sources and encompass external and individual domains (Figure 2.1).[15,16] The external domain includes dimensions of *availability* or the presence of food, *vendor properties* such as when markets are open, *product properties* or quality and safety of food, *marketing* or whether food advertisements were observed, and *stability* whether seasonal fluctuations affect availability and affordability of foods. Personal food environment dimensions are *accessibility* or mobility and proximity to food sources, *affordability* or purchasing power, *convenience* such as time it takes

to prepare or consume foods, *desirability* such as satiability and taste of foods, and *social forces* including cultural preferences surrounding foods.

Figure 2.1: Perceived food environment framework

Food environments in Nepal are complex as individuals acquire foods from multiple sources including informal markets, food stalls, agricultural activities, and formal markets, while individual-level characteristics such as preferences and affordability shape what foods are acquired and ultimately consumed, making food environments difficult to measure.[17–19]

Limited research exists on food environment factors that influence dietary practices among children in LMICs. Conclusions cannot be drawn from existing evidence assessing the relationship between food environment exposures and dietary and nutrition outcomes due to the poor quality of studies evaluating these relationships.[19] Most research on drivers of food choice in LMICs are limited to sub-Saharan Africa with only a few South Asian studies in urban contexts capturing psychological, sociocultural, and external factors that affect food choice.[20] In

a recent global review of studies evaluating drivers of food choice, no studies were conducted in Nepal.[20]

The most popular and widely used food environment (FE) measures have been validated and used in high income countries. However, efforts to develop food environment measures for LMICs are underway.[18] Progress has been made to develop frameworks to classify components of food environments by personal and external domains[15], food environment typology[21], and food desert classification[22] in LMICs. In particular, existing FE measures predominantly focus on collecting objective FE details such as vendor inventories, prices, and distance to markets using physical measures such as geographical positioning (GPS) and store inventories.[19,23,24] Perceived or subjective measures that consider an individual's experiences, or their perceptions of access or affordability of foods are less studied in LMICs. How individuals perceive their access to foods, pricing, convenience, marketing, or affordability of foods are critical to influencing decisions related to acquisition and consumption of foods.[15] Perceived aspects of food environments have been evaluated using qualitative approaches in South America, but no tool exists to assess perceived food environments using quantitative scales.[19] Quantitative scales are useful for collecting large amounts of data and can be used to make generalizable inferences at a population level.

To address this lack of quantitative data, a simple measure of food environments can be used to elucidate factors that influence consumption and diets, which is of particular importance as most LMICs experience a nutrition transition towards a higher burden of diet-related noncommunicable disease.[10,25,26] A food environment measure can help target factors that influence processed food consumption and identify interventions that address barriers to consumption of nutritious foods. Understanding food environments for healthy options in

addition to unhealthy foods is critical. How individuals perceive desirability, access, marketing of ultra-processed foods, or vegetables in LMICs may manifest differently. A validated food environment scale can be helpful to distill the multi-dimensional concept of food environments into a more simple measure to facilitate inferential analysis and communicate findings.[27]

The goal of this research was to address current limitations in measuring FE in LMICs by developing a novel scale to capture perceived food environments in Nepal. The objective was to design a simple FE measure and use the measure to determine associations between food environments and dietary consumption.

2.3 Methods

2.3.1 Overall approach

This study followed seven steps to construct and validate the FE measure: 1) identify initial item list to be included in a perceived food environment measure, 2) expert consultation with food systems and nutrition researchers to refine item list, 3) pilot test the survey items, 4) collect data using the scale in a large-scale household survey in Nepal, 5) validate the scale, 6) construct food environment summaries, and 7) test associations between perceived food environments and dietary outcomes.

We aimed to develop a perceived FE measure adapted to an LMIC context. Several principles guided the development of the FE measure. To reduce costs, facilitate ease of use, and reduce data collection time, we aimed for a parsimonious set of items to capture perceived food environments that reflect the myriad of food sources (grown or purchased food) and contexts (both rural and urban). The scale items included data collection for (1) dark green leafy

vegetables and (2) processed snack foods high in sugar, salt and/or trans or saturated fats to reflect food environments of healthy and unhealthy foods, respectively. We then used the FE measure to assess the relationship between food environments and dietary outcomes.

Step 1: Development of initial item list

The initial list of survey items for the food environment rapid assessment (FERA) measurement scale, a short measure of perceived food environments in Nepal, were inspired by the adapted food environment framework (Figure 2.1). Based on this framework, we adapted survey items from existing tools including the Food Choice Values questionnaire, the Neighborhood Environment Measures Survey – Perceived (NEMS-P), and included newly developed items to capture other food environment dimensions.[28,29] Responses for each item were recorded on a 3-point Likert scale of agree, unsure, or disagree.

Step 2: Expert consultation

We invited nine food environment and nutrition experts to review the list of FERA survey items for feedback and to assess face validity of questions. Food environment and nutrition experts included experts in global nutrition implementation research, food choice assessments, and food systems in Nepal. Written feedback was received from experts on the ease of interpretation of each question and requested suggestions on feedback to improve each question. Feedback included revising "snack food" references to capture processed foods since the word for "snack foods" in Nepali is the same as afternoon snack. To distinguish between the two concepts, we revised the wording to "packaged snack foods" and provided a list of locally available processed foods high in sugar, salt, trans or saturated fats for clarity. Additional modifications included a

thorough revisit of definitions included in the food environment framework (Figure 2.1) to ensure questions accurately reflected the definitions of each dimension. We aimed for parsimony to facilitate inclusion of questions into an ongoing household survey. After review of the item list, the FERA scale included 13 items which were retained for pilot testing.

Step 3: Pilot testing

Using the 13-item scale, we assessed food environments for processed snack foods and dark green leafy vegetables (DGLVs) through a pilot test with 146 women 15-49 years old in Dolkha District, Nepal. The pilot was carried out from July 6-9, 2022 in Bhimeshwor (urban), Baiteswor (rural) and Jiri (urban) municipalities. Respondents were chosen using a convenience sample. Following pilot testing, survey administrators provided feedback to improve comprehension of the survey (including individual items) and further adaptations were made to the questions to reflect the local context. For example, during survey administration it was noted that many rural respondents grow vegetables for consumption as opposed to purchasing all their vegetables. To reflect this, the survey item was adapted to measure product properties: “Vendors near me sell fruits and vegetables that are high quality” to “Dark green leafy vegetables that I have access to are high quality (such as clean and fresh)”.

Step 4: Data collection through monitoring survey in Nepal

Following pilot testing, the FERA was incorporated in the 2022 *Suaahara* II (SII) cross-sectional household monitoring survey led by Helen Keller International and New Era. The survey collected data on children under 5 years of age by interviewing women aged 18-49 years residing in 3,648 households in 42 (55%) of the 77 districts in Nepal. The SII household monitoring

survey employed a multi-stage cluster sampling strategy. The first stage of sampling included 16 randomly chosen districts from the 42 districts participating in SII. For the second stage of sampling, one rural and one urban municipality were randomly chosen within each of the sixteen sampled districts. At the third stage of sampling three wards were sampled from each chosen municipality. At the fourth stage of sampling, two “old” pre-federalism wards were randomly selected from wards. These old wards were considered the cluster. Within each cluster, a random sample of households was selected from a list of eligible households. A total of nineteen households with a child less than five were randomly selected from a list of households in each old ward. The final sample included 3648 households.[30] Population proportionate to size techniques were used at each sampling stage based on population estimates from the 2011 Nepal census. From each participating household, the youngest child was included as the child of focus for the child questionnaire while the child’s mother responded to a mothers’ questionnaire.

Step 5: Content and criterion validation testing

Using data collected through the SII household monitoring survey, we conducted validation tests to assess content and criterion validity of the tool. *Criterion validity* was the degree to which the FERA score was associated with a variable that it should be associated with if it is a valid measure. For example, it was expected that a higher food environment score for DGLVs should be associated with higher consumption of DGLVs. Likewise, the food environment score for processed snack foods should be associated with consumption of processed snacks high in sugar, salt, or unhealthy fats. In this step, we tested the association between food environment scores for healthy and unhealthy foods and consumption of these respective foods. We created a food environment score summing responses from the FERA for packaged snack foods and for DGLVs

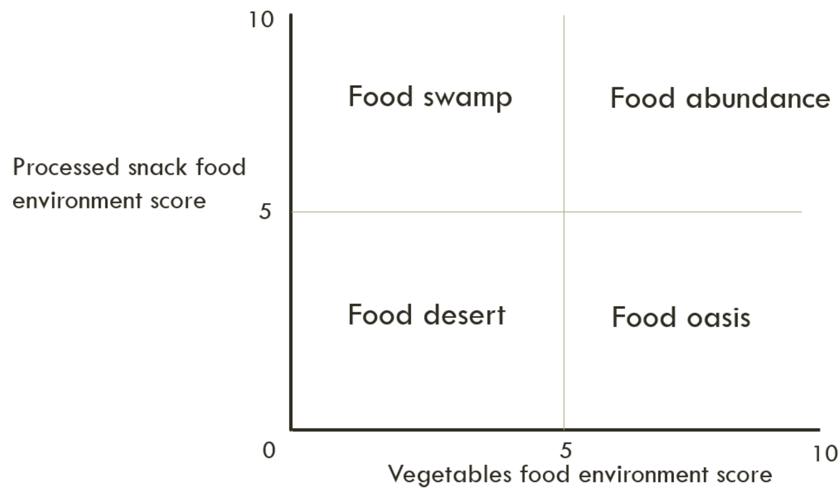
separately. This is also called concurrent validity since the food environment scores and consumption data were collected at the same time point.

If a measure was content valid, the content of a survey should cover all relevant parts of the subject it aimed to measure. To assess *content validity*, we mapped individual indicators from the FERA to the pool of potential FE dimensions to capture the extent to which our scale captured all FE dimensions, similar to methods used in validation of other indices.[31] This validity test was based on the complete food environment framework which involved fourteen FE dimensions, eight under the external domain and six under the personal domain.[15,16] We mapped the number of dimensions measured in the FERA to the fourteen dimensions in the complete FE framework to arrive at a percent of total dimensions captured through the FERA.

Step 6: Food environment data summary measures

We applied two approaches to summarize FE data using the FERA. The first approach involved construction of food environment scores for dark green leafy vegetables (DGLVs) and processed snack foods. FE scores were created by summing the "Agree" responses for each item in the FERA. We used DGLVs as a proxy for micronutrient-rich foods, and processed snack foods as a proxy for processed foods high in sugar, salt, and/or fat. These scores were proxy measures of perceived FEs for healthy and unhealthy foods, respectively. The second method involved classifying households based on combinations of FE scores for DGLVs and processed snack foods by four food environment statuses based on the food desert classification scheme: food abundance, food oasis, food desert, and food swamp (Figure 2.2).[22,32,33]

Figure 2.2: Food environment statuses



Food abundance reflects a situation in which a household had access, availability, convenience, desirability of DGLVs, and at the same time was inundated with marketing, access, convenience of processed snack foods. In a *food oasis*, households had greater access, availability, and affordability of DGLVs, but low overall food environment score for snacks. In *food deserts*, there were many barriers to consumption of both types of food. Lastly, in *food swamps*, households expressed a high score for snack foods, while simultaneously a low food environment score for vegetables. To distinguish these four statuses, we used five as a cut off for DGLV and processed snack food FE scores (Figure 2.2). A household was classified as food abundant when they scored five or above in both DGLV and processed snack food FE scores. Food oasis characterized households with a FE score ≥ 5 for DGLV and < 5 score for processed snack foods. Food swamps captured households with a processed snack FE score of five or above and a DGLV FE score of < 5. Characterizing households across these FE statuses allowed us to classify households according to FE scores combining healthy and unhealthy foods and test associations between FE status and dietary consumption.

Step 7: Test associations between food environments and dietary outcomes

We estimated the associations between the FERA with four dietary consumption indicators, using data collected from the SII household survey. Infant and young child feeding (IYCF) or dietary outcomes were measured by four indicators: (1) minimum dietary diversity (MDD), (2) zero fruit and vegetable consumption, (3) consumption of unhealthy foods and (4) a composite indicator of unhealthy diets. MDD was defined as consuming foods from at least four of the seven recommended food groups in the last 24 hours. The seven food groups were: 1) grains, roots, tubers, plantains, 2) pulses, nuts, seeds, 3) dairy products, 4) flesh foods, 5) eggs, 6) vitamin-A rich fruits and vegetables, 7) other fruits and vegetables.[34] Typically MDD is measured for 6-23 month olds, but it has been validated for use with children 24-59 month olds by other studies, so MDD was presented for all children under five.[35] Zero fruits and vegetable consumption was defined as not consuming either fruits or vegetables in the previous day.[36] Unhealthy consumption was consumption of a sentinel food high in sugar, saturated or trans-fat, and/or salt in the last 24 hours.[8] Unhealthy diets was a composite indicator for not reaching MDD and daily consumption of processed salty or sugary foods. For criterion validity testing, we used the variables consumption of DGLV in the previous 24 hours and consumption of processed salty or sugary foods in the last 24 hours. All consumption data were collected through a qualitative 24 dietary recall survey. Independent variables were food environment scores and individual dimensions for DGLV and processed snack foods and food environment status.

We used Poisson generalized linear mixed effects models using cluster robust standard errors with random intercepts by cluster to estimate prevalence ratios (PR) and 95% confidence intervals (CI) for the four dietary outcomes.[37–39] Since we applied robust standard errors with Poisson regression models, we omitted sample weights since conclusions are similar if sample

weights are used or not.[40] We present prevalence ratios from unadjusted models and models adjusted for all demographic covariates identified *a priori*. Demographic characteristics were identified as potential confounders from the literature.[41] Benjamini-Hochberg (B-H) adjustments were applied to account for multiple testing.[42–44] A false discovery rate of 0.05 was used in the B-H adjustment to identify $p<0.017$ as the cut-off for statistical significance.

2.3.2 Statistical analysis

Descriptive statistics were presented for all covariates including dietary outcomes, food environment measures, and demographic characteristics including means and standard deviations for continuous variables and percentages for categorical variables. The covariates maternal age, maternal education, caste/ethnicity, urban/rural, agro-ecological zone, and the wealth score were collected in the 2022 SII household monitoring survey. Maternal age was presented as a continuous variable, and other covariates were categorical. Maternal education was dichotomized into two levels, secondary education and higher or less than secondary education. Socio-economic well-being was measured using wealth quintiles based on a score for ownership of selected household assets (television, fan, chair, cupboard, sofa and table) and types of housing materials (cooking fuel and floor, roof and wall materials) used in the Nepal Demographic and Health Survey.[45] Agro-ecological zones were categorized as *terai* (plains), mountainous or hill. Caste was defined using three categories, lower caste (including Dalit, Muslim, and disadvantaged Janjati), relatively advantaged (i.e. Newar, Gurung/Thakali, non-Dalit terai caste) and upper (Brahmin and Chhetri).[41,46] Residency was dichotomized into urban and rural according to Nepal classifications.

We checked the correlation matrix and variance inflation factor (VIF) to assess multicollinearity of survey items. Since food environment dimension data were ordinal (3 response categories), polychoric correlations were used to identify multicollinearity among food environment items. Polychoric correlations capture more variation than Pearsons correlation and is recommended for ordinal variables.[47] VIFs were calculated for each FE dimension as a test for multicollinearity with a recommendation that VIFs greater than five warranted investigation and exceeding ten was an indication of multicollinearity and required correction.[48,49] We removed one item if two survey items were highly correlated (ρ>0.90) and removed questions that had less than 3% variability in response probabilities as this was not ideal for regression modeling. If items had less than 3% variability but captured a unique dimension of the food environment framework not covered by another item, it was retained for content validity.

All statistical analysis was conducted using R version 4.2.2. The Nepal Health Research Council (Reg no. 212/2021) approved the conduct of this research.

2.4 Results

2.4.1 Development of the Food Environment Rapid Assessment scale

The final set of FERA items were selected after running correlation tests to avoid multicollinearity using the SII household survey data. Several (n=3) items were removed to avoid redundancy and reduce multicollinearity. The item "I do not know of any vendors/shops who sell [food item]" was removed as it was highly correlated with "I know of many vendors/shops who sell [food item]", and both were measures of availability (ρ=-0.96). The items "I like the taste of [food item]" and "[Food items] are healthy for me or my child" were

removed because they had less than 3% variability in response probabilities for DGLVs and the dimension of desirability was captured in the question "[Food item] fills my stomach". We retained the item "[Food item] are fast and easy to prepare, in general" even though there was less than 3% variability in responses to retain sufficient content validity. These changes reduced multicollinearity between FE dimensions, where the VIF of the final FERA items were all less than two and ranged from 1.04-1.23. The FERA scale included ten items for DGLVs and ten items for processed snack foods. FERA scores ranged from 1-10 for each food arrived by summing the "Agree" responses for each food. Table 2.1 presents the final list of items included in the FERA for DGLV. The same list of items was included in the FERA for processed foods, where 'processed foods' replaced references to DGLVs.

Table 2.1: Food environment rapid assessment survey items for dark green leafy vegetables

		Agree	Neither agree nor disagree	Disagree	**FE dimension assessed**
External domain					
1	I know of many vendors/shops who sell dark green leafy vegetables				**Availability**
2	Dark green leafy vegetables are available all year round				**Stability**
3	Dark green leafy vegetables that I have access to are high quality (such as clean and fresh)				**Product properties**
4	Vendors/shops near me selling dark green leafy vegetables are open at convenient times for me => skip if they do not buy vegetables				**Vendor properties**
5	I notice signs, displays, or advertisements encouraging me to purchase dark green leafy vegetables				**Marketing**
Personal domain					
6	It is easy to acquire dark green leafy vegetables close to where I spend most of my time				**Accessibility**
7	I can afford to buy dark green leafy vegetables				**Affordability**
8	Dark green leafy vegetables are fast and easy to prepare, in general				**Convenience**
9	Eating dark green leafy vegetables fills my stomach				**Desirability**
10	My child and family enjoy eating dark green leafy vegetables				**Social forces**

2.4.2 Validity testing

Feedback from food systems and nutrition experts confirmed that concepts in the FERA reflected the intended FE dimensions and adequately reflected face validity. Assessment for content validity demonstrated the FERA covered 79% of food environment dimensions (11/14). The dimensions not covered by FERA included prices, wider food system drivers, and gender dynamics. Criterion validity tests showed that food environment scores for processed snack foods and DGLVs performed as expected. FE scores for processed foods were significantly associated with unhealthy consumption ($p<0.001$) and FE DGLV scores were significantly associated with consumption of DGLVs in the previous day ($p<0.001$).

2.4.3 Associations between food environment and dietary outcomes

For the primary analysis between food environments and dietary outcomes, we used food environment data incorporated into the SII monitoring survey along with other key household characteristics regularly collected as part of the survey. Table 2.2 summarizes demographic characteristics of the study population. Most respondents of the SII survey received less than secondary school education, represent the middle three wealth quintiles, lived in Hill areas, and were from a socially excluded caste. When considering dietary outcomes, 56.4% of children under five years of age reported achieving MDD, while 8.4% had an unhealthy diet. Respondents reported that DGLVs were perceived to be convenient (98.4%), desirable (92.7%), and that families enjoyed consuming DGLVs (89.8%). Processed snack foods were available for 93.6% of the study population, available year-round (93.0%), accessible (86.1%), affordable (90.1%), and convenient (82.8%) (Table 2.2).

Most households resided in areas of food abundance (82.4%), followed by food swamps (9.0%), and food oasis (6.0%) with the lowest percentage living in food deserts (2.6%).

Table 2.2: Demographic characteristics for Suaahara II 2022 annual survey

		Overall (N=3648)
Ecological zone, n (%)		
	Terai	1140 (31.3%)
	Hill	2052 (56.3%)
	Mountain	456 (12.5%)
Residency, n (%)		
	Rural	1824 (50.0%)
	Urban	1824 (50.0%)
Equity quintile, n (%)		
	Lowest	358 (9.8%)
	Second lowest	825 (22.6%)
	Middle	907 (24.9%)
	Second highest	1143 (31.3%)
	Highest	415 (11.4%)
Maternal education level, n (%)		
	Less than secondary school	2327 (63.8%)
	Secondary school or higher	1321 (36.2%)
Caste, n (%)		
	Socially excluded	2011 (55.1%)
	Brahmin	1317 (36.1%)
	Others	320 (8.8%)
FE score, mean (SD)		
	DGLV (0-10)	7.02 (1.97)
	Processed snack food (0-10)	7.25 (1.86)
FE status, n (%)		
	Food abundance	3006 (82.4%)
	Food oasis	220 (6.0%)
	Food swamp	327 (9.0%)
	Food desert	95 (2.6%)
Dietary outcomes among children < 5 years, n (%)		
	Minimum Dietary Diversity	2057 (56.4%)

Zero Fruit and Vegetable consumption	928 (25.4%)
Unhealthy consumption	1878 (51.5%)
Unhealthy diets	305 (8.4%)
DGLV FE dimensions, n (%)	
Availability	59.7%
Stability	55.5%
Product properties	74.8%
Vendor properties	24.8%
Marketing	59.3%
Accessibility	69.6%
Affordability	77.6%
Convenience	98.4%
Desirability	92.7%
Social forces	89.8%
Processed snack food FE dimensions, n (%)	
Availability	93.6%
Stability	93.0%
Product properties	51.6%
Vendor properties	80.6%
Marketing	64.7%
Accessibility	86.1%
Affordability	90.1%
Convenience	82.8%
Desirability	38.8%
Social forces	44.1%

Food environment scores averaged 7 out of 10 for DGLVs and packaged snack foods. Scores were highest among wealthier, more educated, rural, and hill area households (Table 2.3). Food environment scores increased by wealth quintile with higher FE scores among the wealthiest households and lower scores for poorer households for both foods (Table 2.3). DGLV food environment scores were higher among households where mothers had secondary school or higher education, and processed food FE scores were higher among households where mothers received less than a secondary school education. Rural households and those residing in Hill zones had overall higher FE scores for both healthy and unhealthy foods.

Table 2.3: Food environment scores and IYCF indicators by demographic covariates

		Food environment scores		Dietary outcomes			
	N	**Processed snack FE score Mean (SD)**	**DGLV FE score Mean (SD)**	**MDD n (%)**	**Zero fruits and vegetables n (%)**	**Unhealthy consumption n (%)**	**Unhealthy diets n (%)**
Overall	3648	7.25 (1.86)	7.02 (1.97)	2057 (56.4%)	927 (25.4%)	1879 (51.5%)	305 (8.36%)
Ecological zone							
Terai	1140	7.16 (1.80)	6.58 (2.25)	553 (48.5%)	294 (25.8%)	632 (55.4%)	149 (13.1%)
Hill	2052	7.30 (1.89)	7.26 (1.82)	1221 (59.5%)	507 (24.7%)	1047 (51%)	136 (6.63%)
Mountain	456	7.27 (1.92)	7.09 (1.64)	284 (62.3%)	128 (28.1%)	201 (44.1%)	20 (4.39%)
Residency							
Rural	1824	7.31 (1.80)	7.14 (1.96)	1005 (55.1%)	469 (25.7%)	938 (51.4%)	154 (8.44%)
Urban	1824	7.20 (1.93)	6.91 (1.97)	1052 (57.7%)	460 (25.2%)	941 (51.6%)	151 (8.28%)
Equity quintile							
Lowest	358	6.84 (2.18)	6.30 (1.91)	189 (52.8%)	106 (29.6%)	136 (38%)	15 (4.19%)
Second lowest	825	7.32 (1.97)	6.99 (1.90)	427 (51.8%)	211 (25.6%)	376 (45.6%)	48 (5.82%)
Middle	907	7.17 (1.85)	7.13 (2.00)	521 (57.4%)	219 (24.1%)	469 (51.7%)	86 (9.48%)
Second highest	1143	7.32 (1.77)	7.02 (2.00)	656 (57.4%)	282 (24.7%)	644 (56.3%)	115 (10.1%)
Highest	415	7.47 (1.56)	7.49 (1.82)	264 (63.6%)	110 (26.5%)	254 (61.2%)	41 (9.88%)
Maternal education level							
Less than secondary school	2327	7.35 (1.91)	6.90 (2.01)	1194 (51.3%)	603 (25.9%)	1217 (52.3%)	240 (10.3%)
Secondary school or higher	1321	7.09 (1.78)	7.24 (1.87)	863 (65.3%)	325 (24.6%)	661 (50%)	66 (5%)
Caste							
Socially excluded	2011	7.31 (1.84)	7.08 (1.90)	1068 (53.1%)	511 (25.4%)	1100 (54.7%)	185 (9.2%)
Brahmin	1317	7.10 (1.94)	6.94 (2.02)	828 (62.9%)	328 (24.9%)	562 (42.7%)	64 (4.86%)
Others	320	7.56 (1.68)	6.98 (2.16)	162 (50.6%)	90 (28.1%)	214 (66.9%)	56 (17.5%)

MDD: Minimum Dietary Diversity (≥4 of 7 food groups); Unhealthy consumption: Consumption of sentinel unhealthy food in the last 24h; Unhealthy diet: Not reaching MDD and consumed processed food high in sugar, salt on a daily basis or more frequently

For overall food environment scores, the model estimates indicate that higher DGLV scores were associated with reaching MDD (aPR=1.04, 95% CI: 1.01, 1.06), while higher processed snack food scores were associated with unhealthy diets (aPR=1.14, 95% CI: 1.07, 1.23), and unhealthy consumption (aPR=1.05, 95% CI: 1.02, 1.08) (Tables 2.4 and 2.5).

FE dimensions associated with MDD were product properties such as cleanliness and freshness (aPR=1.17, 95% CI: 1.04, 1.30), stability or year-round access (aPR=1.12, 95% CI: 1.02, 1.22), and accessibility (aPR=1.14, 95% CI: 1.03, 1.26) of DGLVs (Table 2.5). Year-round access to DGLVs was associated with a 15% lower prevalence of zero fruit and vegetable consumption (p=0.014).

Snack food environment dimensions associated with unhealthy consumption included availability (aPR=1.35, 95% CI: 1.08, 1.68), marketing (aPR=1.13, 95% CI: 1.03, 1.25), product properties (aPR=1.12, 95% CI: 1.02, 1.23), and convenience (aPR = 1.23, 95% CI: 1.08, 1.41) (Table 2.4). Vendor properties such as whether processed food vendors are open at convenient hours for customers, was associated with a 55% higher prevalence of an unhealthy diet (p=0.013) and those finding processed foods convenient were at a 2.31 times higher prevalence of consuming an unhealthy diet than those that did not find processed foods convenient (p<0.001). Higher availability of snack foods was inversely related to zero fruit and vegetable consumption (p=0.003).

In terms of food environment type, living in an area of food abundance was associated with both a 21% higher prevalence of consuming processed snack foods (p=0.004), and 17% lower prevalence of no fruit and vegetable consumption (p=0.022) (Table 2.6). However, living in a food swamp (high FE scores for processed snack foods and low FE scores for DGLVs) was associated

Table 2.4: Associations between snack food environment dimensions and child dietary outcomes

	Unhealthy diet, aPR (95% CI)	***p***	**Zero F&V consumption, aPR (95% CI)**	***p***	**Unhealthy consumption, aPR (95% CI)**	***p***	**MDD, aPR (95% CI)**	***p***
Overall snack FE score	**1.14 (1.07 – 1.23)**	**<0.001****	0.99 (0.96 – 1.03)	0.668	**1.05 (1.02 – 1.08)**	**<0.001****	1 (0.97 – 1.02)	0.826
Food environment dimensions								
Availability	1.61 (0.90 – 2.88)	0.109	**0.71 (0.56 – 0.89)**	**0.003***	**1.35 (1.08 – 1.68)**	**0.007***	1.09 (0.90 – 1.32)	0.371
Vendor properties	**1.55 (1.10 – 2.18)**	**0.013***	0.9 (0.77 – 1.06)	0.203	1.11 (0.98 – 1.25)	0.1	1.06 (0.94 – 1.18)	0.338
Marketing	1.12 (0.88 – 1.44)	0.356	0.98 (0.86 – 1.13)	0.805	**1.13 (1.03 – 1.25)**	**0.014***	1.02 (0.93 – 1.12)	0.681
Affordability	1.47 (0.93 – 2.32)	0.101	0.97 (0.78 – 1.20)	0.779	1.17 (0.99 – 1.38)	0.065	1.06 (0.91 – 1.24)	0.436
Product properties	1.28 (1.01 – 1.62)	0.037	0.98 (0.86 – 1.12)	0.779	**1.12 (1.02 – 1.23)**	**0.016***	0.98 (0.89 – 1.07)	0.591
Stability	1.05 (0.64 – 1.72)	0.855	0.84 (0.66 – 1.06)	0.134	1.07 (0.89 – 1.30)	0.48	1.1 (0.92 – 1.32)	0.288
Accessibility	1.3 (0.88 – 1.93)	0.191	1.03 (0.85 – 1.24)	0.773	1.09 (0.95 – 1.26)	0.236	0.97 (0.86 – 1.10)	0.665
Convenience	**2.31 (1.51 – 3.54)**	**<0.001***	0.93 (0.79 – 1.11)	0.426	**1.23 (1.08 – 1.41)**	**0.002***	0.99 (0.88 – 1.11)	0.860
Desirability	1.22 (0.97 – 1.54)	0.093	1.16 (1.02 – 1.33)	0.026	1.02 (0.93 – 1.13)	0.616	0.94 (0.86 – 1.03)	0.214
Social forces	1.28 (1.02 – 1.62)	0.035	1.04 (0.91 – 1.19)	0.557	1.06 (0.97 – 1.17)	0.22	0.94 (0.86 – 1.03)	0.206

Abbreviations: MDD=Minimum dietary diversity (≥4 of 7 food groups), aPR=adjusted prevalence ratio, CI=confidence interval, F&V=fruit and vegetable, FE=food environment; Unhealthy consumption: Consumption of sentinel unhealthy food in the last 24h; Unhealthy diet: Not reaching MDD and consumed processed food high in sugar, salt on a daily basis or more frequently; All models adjusted for maternal age, maternal education, caste/ethnicity, urban/rural, agro-ecological zone, and wealth score

Table 2.5: Associations between dark green leafy vegetable food environment dimensions and child dietary outcomes

	Unhealthy diet, aPR (95% CI)	p	Zero F&V consumption, aPR (95% CI)	p	Unhealthy consumption, aPR (95% CI)	*p*	MDD, aPR (95% CI)	*p*
Overall DGLV FE score	0.97 (0.92 – 1.03)	0.373	0.97 (0.93 – 1.00)	0.042	1.03 (1.00 – 1.05)	0.032	**1.04 (1.01 – 1.06)**	**0.004***
Food environment dimensions								
Availability	1.09 (0.86 – 1.38)	0.474	0.94 (0.82 – 1.07)	0.364	**1.13 (1.02 – 1.24)**	**0.015***	1.08 (0.99 – 1.18)	0.098
Vendor properties	1.04 (0.80 – 1.35)	0.788	1.06 (0.92 – 1.23)	0.428	0.97 (0.87 – 1.08)	0.572	1.04 (0.94 – 1.15)	0.402
Marketing	0.93 (0.74 – 1.18)	0.566	0.94 (0.82 – 1.07)	0.359	1.11 (1.01 – 1.22)	0.038	1.06 (0.97 – 1.16)	0.23
Affordability	1.21 (0.89 – 1.65)	0.228	1.15 (0.98 – 1.35)	0.096	1.02 (0.91 – 1.14)	0.714	0.96 (0.86 – 1.07)	0.453
Product properties	0.76 (0.59 – 0.98)	0.034	0.84 (0.72 – 0.97)	0.018	1.03 (0.92 – 1.14)	0.647	**1.17 (1.04 – 1.30)**	**0.006***
Stability	0.9 (0.71 – 1.13)	0.352	**0.85 (0.74 – 0.97)**	**0.014***	1.05 (0.96 – 1.16)	0.261	**1.12 (1.02 – 1.22)**	**0.013***
Accessibility	0.82 (0.64 – 1.04)	0.104	0.89 (0.78 – 1.03)	0.123	1.12 (1.01 – 1.24)	0.035	**1.14 (1.03 – 1.26)**	**0.009***
Convenience	0.78 (0.32 – 1.89)	0.575	1.15 (0.67 – 2.00)	0.608	0.91 (0.64 – 1.30)	0.601	0.89 (0.64 – 1.23)	0.488
Desirability	1.05 (0.68 – 1.61)	0.832	0.78 (0.63 – 0.98)	0.036	1.05 (0.88 – 1.26)	0.585	1.13 (0.94 – 1.35)	0.19
Social forces	0.82 (0.59 – 1.14)	0.237	0.83 (0.68 – 1.01)	0.06	1.03 (0.89 – 1.20)	0.665	1.09 (0.93 – 1.27)	0.278

Abbreviations: aPR=adjusted prevalence radio, MDD=minimum dietary diversity (≥4 of 7 food groups), CI=confidence interval; All models adjusted for maternal age, maternal education, caste/ethnicity, urban/rural, agro-ecological zone, and wealth score; Unhealthy consumption: Consumption of sentinel unhealthy food in the last 24h; Unhealthy diet: Not reaching MDD and consumed processed food high in sugar, salt on a daily basis or more frequently

with a 21% lower prevalence of achieving MDD (p=0.008). Living in food deserts was associated with a 54% higher prevalence of not consuming any fruits or vegetables (p=0.011).

Table 2.6: Associations between food status and child dietary outcomes

	Unhealthy diet, aPR (95% CI)	***p***	**Zero F&V consumption, aPR (95% CI)**	***p***	**Unhealthy consumption, aPR (95% CI)**	***p***	**MDD, aPR (95% CI)**	***p***
Food abundance	1.06 (0.78 – 1.43)	0.707	**0.83 (0.70 – 0.97)**	**0.022**	**1.21 (1.06 – 1.38)**	**0.004**	1.15 (1.02 – 1.30)	0.025
Food oasis	0.44 (0.21 – 0.93)	0.031	1 (0.77 – 1.32)	0.972	0.79 (0.63 – 0.98)	0.032	1.07 (0.89 – 1.28)	0.471
Food swamp	1.21 (0.86 – 1.71)	0.279	1.19 (0.96 – 1.47)	0.119	0.91 (0.77 – 1.07)	0.26	**0.79 (0.66 – 0.94)**	**0.008**
Food desert	1.02 (0.50 – 2.07)	0.961	**1.54 (1.10 – 2.14)**	**0.011**	0.77 (0.55 – 1.07)	0.119	0.75 (0.55 – 1.04)	0.081

Abbreviations: aPR=adjusted prevalence ratio, MDD=minimum dietary diversity, CI=confidence interval

2.5 Discussion

The objective of this study was to develop a food environment measurement tool appropriate for an LMIC context. The resulting FERA scale includes ten items that capture external and personal domains and dimensions related to healthy and unhealthy foods for DGLVs and processed snack foods, respectively. This tool consisted of a parsimonious set of food environment items that was feasible and successfully integrated into an ongoing SII household monitoring survey that sampled approximately 65% of Nepal's households.

This tool reflected adequate face, content, and criterion validity. Face validity was captured through expert consultation and vetting of questions by nine food systems and environment experts. Incorporation of feedback from experts ensured that the questions successfully captured FE dimensions. Content validity assessment demonstrated that the tool captured 79% of all food

environment dimensions. The FERA is more comprehensive in covering dimensions of the FE framework than existing quantitative FE measures.[19] Existing FE tools cover no more than 63% of dimensions (5/8) with gaps in measures covering perceived convenience and product properties such as food safety, and affordability.[19,20] While the survey items covered most FE dimensions, several FE components were not covered in the FERA. As a subjective or perceived measure of food environments, the FERA did not measure prices, which are often measured through market surveys or using food price data. We instead captured affordability to obtain information on the perceived ability to purchase food items, a proxy for whether prices were low enough for purchase. Wider food system drivers and gender dynamics were also not covered through the FERA because these would require extensive multilayer questioning. Gender dynamics can be captured through other tools adapted for agriculture and nutrition programs, but require more extensive questioning.[50,51] Since a goal of the FERA was to be parsimonious, we could not adequately include these dimensions in the item list.

Criterion validity tests demonstrated that FE scores for DGLV and processed snack foods were highly associated with consumption of these foods. These results reflect the established relationships between healthier food environments for vegetables and increased consumption of vegetables.[52–60] Similarly, food environments for unhealthy foods influenced ultra-processed food intake.[2,61] The FERA was highly correlated with known auxiliary variables and behaved as expected.

Using the FERA, we underscored the association between food environments and dietary indicators. Higher food environment scores for DGLVs were associated with reaching MDD and a one-point increase in processed food FE score was associated with a 5% higher prevalence of unhealthy diets and 14% higher prevalence of consuming processed foods high in sugar and salt.

Food environments favoring processed snack foods was associated with greater consumption of unhealthier food options and unhealthy diets. This corroborates findings that the environments where we spend our time shape what we eat.[17,62]

The links between food environments and diets highlight the increased urgency to center discussions and potential solutions to improved food systems and nutrition outcomes within the context of the nutrition transition occurring within Nepal and South Asia.[10,63] Recent shifts in the food economy within Nepal have undermined food security and livelihoods resulting in greater dependence on nutrient poor, convenient, cheaper foods.[64] These shifts led by the rise of commercial industries producing cheap, low-nutrient foods have translated to greater consumption of ultra-processed foods in both urban and rural areas. Our study demonstrated that the FE dimensions of convenience, availability, marketing, and vendors opening at reasonable hours selling nutrient-poor processed foods significantly influenced unhealthy food consumption. Convenience of processed snack foods had the strongest associations with unhealthy consumption, by more than doubling the prevalence of consuming an unhealthy diet. This finding supports the literature that convenience of processed foods is significantly associated with food choice in Kenya,[17] Vietnam[65], and India.[57] Marketing of snack foods was also associated with a higher prevalence of consuming nutrient-poor foods. Global entities such as the World Health Organization (WHO), the Food and Agriculture Organization, and United National Children's Fund (UNICEF) have called for greater regulation of marketing of ultra-processed foods through increased taxation, restrictions on advertising, and required labelling.[13,66,67] Children are especially vulnerable to marketing of unhealthy foods and specific policies are needed to limit advertisements targeting young children. Chile has successfully enacted policies to restrict advertising and marketing of unhealthy foods to children, and required label warnings

for all foods excessively high in added sugar, saturated fat, or sodium.[68,69] Currently there are no policies on reducing excess salt consumption, sugary beverage taxation, elimination of trans fat intake, or reducing marketing of ultra-processed foods on children in Nepal, which is out of line with WHO recommendations.[70–73] A need for careful review of food policies and restricting advertisement of unhealthy foods to children in agreement with global recommendations can help to reduce the main risk factors for noncommunicable diseases.

In contrast to FE drivers for processed foods, households that had access to DGLVs that were considered clean and safe and available year-round had a 12-17% higher prevalence of reaching MDD compared to households that did not. A recent systematic review showed that concerns around cleanliness, quality, and freshness of vegetables influence what consumers purchase and consume in LMICs.[74] Concerns with food safety reduce consumption of vegetables while simultaneously increase consumption of processed foods. Policies to reduce food contamination, adulteration of food, and improve handling of fresh vegetables can have important implications on dietary decisions.[75] Education campaigns targeting vendors, enforcement of food safety guidelines, and certification initiatives can contribute to this effort. Ensuring safe and clean foods are available *across seasons* is also an important aspect that shapes consumption. Seasonal fluctuations in the availability, access, and affordability of vegetables influenced dietary consumption among different agroecological zones and was an important factor associated with food choice in Nepal. The SII survey took place in the monsoon season, characterized by higher consumption of vegetables compared to the post-monsoon season.[76] Access and availability of DGLVs change with the seasons especially in areas more dependent on agricultural production. Future research to collect data in multiple seasons is warranted to understand how FEs change by season.

We applied a food environment classification scheme to classify households as living in food deserts, food swamps, food oases, or food abundance. A food oasis is the most preferable situation, where the ratio between DGLV and processed snack food environment scores were greater than one. In the study population, six percent of households lived in a food oasis. Further research should capture characteristics of living in these areas, as well as determinants and enablers of living in a food oasis. Simultaneously, it is important to identify characteristics linked to living in food deserts and food swamps as food environments in these areas are more amenable to processed snack foods than vegetables. Mixed methods research has the potential to better characterize these environments in Nepal. Ultimately using information on factors that influence food environment classifications can help to inform interventions that could be adopted to improve food environments for sections of the population. Lastly, living in a food abundant area, marked by high FE scores for both vegetables and processed snack foods, was associated with a 21% higher prevalence of consumption of unhealthy foods and 15% higher prevalence of reaching MDD. Most respondents lived in food abundance, indicating that these individuals had more choices between consuming healthy and unhealthy foods. Interestingly, if there were fewer barriers to consuming processed foods and vegetables, often a choice was made to consume the more convenient and cheaper food. More targeted social and behavior change interventions in conjunction with structural changes to disrupt the commercial determinants of unhealthy consumption are needed to foster environments that nudge individuals to make healthier choices.

2.5.1 Limitations

We were unable to assess inter-rater reliability of the FERA since the scale was asked only once to participants in the pilot and in the cross-sectional survey. This was due to logistic constraints

and to reduce the time burden on respondents. Future reliability testing will be important to ensure that conclusions are not influenced by social desirability bias and measurement error. Another limitation was that data were collected at one point in time using a cross-sectional survey allowing inference of association and not causality. Thus, the directionality of associations is unclear. For example, the desire to achieve a more diverse diet could lead an individual to move into a food oasis area, rather than living in food oasis areas leading to healthier consumption. Irrespective of directionality, the associations support relationships between food environments and consumption.

This study was unable to assess construct validity of FERA. Applying methods such as cognitive testing could strengthen development of the survey items and provide additional evidence of a validated scale. Instead, we assessed face, content, and criterion validity and pilot tested the scale to obtain feedback on the set of items before launching data collection. Pilot testing involved an ample sample size (n=146 women) and involved households from both rural and urban areas. Though more aspects of validity were not able to be included, this study demonstrates that the FERA achieves content, face, and criterion valid for use in Nepal.

2.6 CONCLUSION

As most LMICs are experiencing a nutrition transition to greater consumption of ultra processed foods and unhealthier overall diets, understanding food environments is of critical concern. We present a validated tool to assess perceived food environments in Nepal, with potential to be adapted to other LMICs. The FERA collecting data on DGLVs and processed snack foods can be added to household monitoring surveys to facilitate comparisons between healthy and unhealthy foods and to understand relationships between food environments and dietary outcomes. Food

environments influence diets among children under five years of age highlighting the urgent need for policy, structural, and interpersonal interventions to shape healthier diets to curb the growing double burden of malnutrition in LMICs.

2.6.1 Future steps

This study used data on proxies for consumption of both healthy and unhealthy foods. Future research should collect FE data on additional foods to achieve a more comprehensive picture of overall food environments, including other healthy foods (vitamin A rich fruits and vegetables, animal sourced foods) and unhealthy foods (such as sugar sweetened beverages). The FERA could also be applied to schools, workplace, prisons, and healthcare settings to assess food environments in the places where individuals spend a lot of their time.

The FERA focuses on capturing information on perceived food environments, but this can be coupled with objective food environment measures to ascertain further information on physical availability of foods at markets or food outlets, prices of food products, inventories of food vendors (vendor properties), and distances to food outlets and vendors. Mixed method approaches are warranted to complement the FERA and gather more holistic data on how food environments shape decisions around consumption.

Chapter 3. Behavioral determinants of infant and young child feeding practices

3.1 Abstract

Introduction: Infant and young child nutrition in the first 1000 days post conception lays the foundation for growth and productivity later in life. Appropriate infant and young child feeding (IYCF) practices are sub-optimal in Nepal with 56% of children 0-5.9 months exclusively breastfed and 48% of children 6-23.9 months reaching minimum dietary diversity. Understanding behavioral determinants of breastfeeding and complementary feeding practices is necessary to design tailored behavior change strategies that address gaps in IYCF practices.

Methods: We employed the Theoretical Domains Framework (TDF), an integrative implementation science framework that synthesizes information from 33 behavior change theories to retrospectively identify behavioral determinants of key IYCF practices. We used four years of *Suaahara* II annual household monitoring survey data in the analysis. We assessed determinants of timely introduction of complementary feeding, exclusive breastfeeding, and child dietary diversity using bivariate and multivariate Poisson mixed effects regression models. Meeting with female community health volunteers (FCHVs) was assessed for effect modification between significant TDF constructs and dietary diversity.

Results: TDF domains of skills and social/professional role and identity were significantly associated with dietary diversity. Specifically, responsive feeding skills (aPR: 1.25, 95% CI: 1.17-1.33) and active participation in community health groups were associated with child dietary diversity score (aPR: 1.19, 95% CI: 1.06 – 1.34). Knowledge was associated with timely introduction of complementary foods (aPR:1.26, 95% CI: 1.12-1.41). FCHV interaction

modified the relationship between responsive feeding skills and dietary diversity score ($p=0.014$).

Conclusions: Future behavior change programs aimed at improving infant and young child feeding practices in Nepal can focus on building responsive feeding skills and invest in increasing participation in FCHV-led community health groups. FCHVs play an important role in providing community-level support to improve child dietary outcomes.

3.2 INTRODUCTION

Optimal infant and young child nutrition during the first 1000 days of life lays a foundation for growth and productivity across the life course.[4] Appropriate infant and young child feeding (IYCF) is an immediate determinant of diet and nutritional outcomes. Though practice of infant and young child feeding behaviors in Nepal has improved in the last several decades, the prevalence of exclusive breastfeeding and minimum dietary diversity remains sub-optimal with only 48.2% of children 6-24 months achieving minimum dietary diversity and 56.4% of children under six months exclusively breastfed.[1] Gains have been made to diversify diets and improve infant feeding including through investments in nutrition-sensitive agriculture interventions and the establishment of a national multi-sectoral nutrition strategy (MSNP). Under the MSNP, the Government of Nepal employs a multi-prong community to facilitate strategies to support families through the life course. The MSNP specifically supports a cadre of 50,000 female community health volunteers (FCHVs) to provide counseling and targeted behavior change communication messaging with an emphasis on improving practice of key infant and young child nutrition behaviors.[77–79] FCHVs increase the reach and frequency of behavioral change communication through facilitating health mothers groups (HMG) meetings and conducting home visits to families within the 1000 day window, but the degree to which exposure to FCHVs influences optimal nutrition behaviors during the first two years of life is unknown.

In addition, identification of caregiver-level behavioral determinants of child feeding behaviors is important to improve behavior change strategies involving FCHVs and to improve IYCF practices more holistically. Multiple studies have identified factors associated with IYCF practices in Nepal. Studies suggest that maternal age, antenatal and postnatal visits, household food security, geographical location, socio-economic status are factors associated with exclusive

breastfeeding and complementary feeding in Nepal, but behavioral determinants of IYCF practices have been less explored.[80–82] Applying a behavioral framework to systematically identify behavioral factors that influence uptake of IYCF practices can inform the design of future behavior change strategies to achieve improvements in IYCF behaviors. This study examined caregiver behavioral determinants of exclusive breastfeeding and complementary feeding practices and the role of FCHV interactions on IYCF practices in Nepal.

3.3 METHODS

3.3.1 Overall approach

To identify key factors influencing the practice of key infant and young child feeding behaviors, we employed an adapted Theoretical Domains Framework (TDF), a widely used integrative framework that synthesizes information from thirty-three behavior change theories to assess behavioral and implementation determinants.[83] The TDF comprises 12 domains with constructs embedded within each domain.[84,85] The goal of the framework was to make behavior change theories accessible for wider audiences involved in designing, implementing, and evaluating interventions.[86] We use regression analysis to explore associations between behavioral factors identified using TDF and IYCF outcomes controlling for household, mother, and child-level characteristics identified as potential confounders from the literature and assessed whether interactions with FCHVs modified these relationships.[41,71,87]

3.3.2 Data sources

We used the 2017, 2018, 2019 and 2022 *Suaahara* II (SII) annual household surveys to assess determinants of timely introduction of complementary feeding, exclusive breastfeeding for the first six months, and dietary diversity for children. The SII annual surveys were conducted among participants of the SII program over the six years of implementation and in the same months (June -September) each year. The annual surveys planned in 2020 and 2021 were canceled due to COVID-restrictions on movement in Nepal. The surveys employed a repeat cross-sectional design with multi-stage cluster sampling returning to the same clusters each year. Surveys randomly sampled sixteen districts, one rural and one urban municipality per district, three wards per municipality, and two sub-wards (clusters) per ward each year. Each year, nineteen households with a child less than five years of age were randomly selected from household lists in each cluster. If more than one child under five resided in the household, the youngest child was chosen for participation.[41] This sampling strategy resulted in approximately 3650 households included in each annual survey.[30] Population proportionate to size techniques were used at each sampling stage based on population sizes from the 2011 Nepal census. Decisions were made to reduce the length of the survey questionnaire in 2018 and 2019 so variables on skills with child feeding, challenges with child feeding, leadership and cohesion in health mothers' group were not collected in these years. In 2022, the survey length was considerably reduced compared to previous years and only included demographic characteristics, knowledge, and IYCF practices due to budget constraints.

3.3.3 Variables

The key IYCF measures of exclusive breastfeeding for children under six months of age, minimum dietary diversity (MDD), and timely introduction of solid/semi solid foods were included as dependent variables. These variables were collected using a semi-quantitative 24-hour recall method. Exclusive breastfeeding was defined as an infant consuming only breastmilk for the first six months of life. Dietary diversity score was calculated as the sum of all food groups consumed by the child, while MDD was defined as consuming foods from at least 4 of 7 food groups.[34] The seven food groups assessed through recall were 1) grains, roots, tubers, plantains, 2) pulses, nuts, seeds, 3) dairy products, 4) flesh foods, 5) eggs, 6) vitamin-A rich fruits and vegetables, 8) other fruits and vegetables.[34] Timely introduction to solid/semi solid foods was the introduction of solid or semi-solid food between 6-8.9 months of age.

We used domains from the Theoretical Domains Framework (TDF) to identify determinants of behavioral uptake and pre-specified demographic constructs as independent variables. We obtained questionnaires from the four annual SII surveys and retrospectively identified survey questions corresponding to TDF domains. We mapped these questions to corresponding constructs under each domain. Definitions for each of the TDF constructs can be found in Table 3.1. Three constructs were included under the *knowledge* domain: knowledge of breastfeeding, knowledge of complementary feeding, and knowledge of home gardening benefits. Specifically, under the knowledge of breastfeeding construct, four questions were incorporated into the SII surveys. To incorporate information from all four questions (knowledge of exclusive breastfeeding, knowledge of exclusive breastfeeding to six months, timely initiation of breastfeeding, and provision of colostrum to newborns), we constructed a breastfeeding knowledge score by summing individual "Yes" responses to each of the four breastfeeding

questions to arrive at a knowledge of breastfeeding score ranging from 0-4 for each respondent. Under the *skills* domain, two constructs were included for responsive feeding competencies. The first construct captured skills in listening to infant hunger cues and not forcing a child to eat when they are fussy or refusing to eat. The second construct captured caregiver competencies of managing a child with a low appetite over several days. The constructs of self-confidence, empowerment, and self-efficacy were assessed under the *beliefs about capabilities* domain. Self-confidence measured the level of certainty a mother had in her ability to accomplish difficult tasks. Empowerment reflected the control a mother had over making decisions about feeding her child. Two constructs were identified under the *behavioral regulation* domain, namely challenges with breastfeeding and challenges with feeding semi-solid/solid foods. *Social influences* domain was measured using the social support construct, namely support for feeding complementary foods from other members of the household. Group/social identity and organizational commitment were constructs measured under the *social/professional role and identity* domain. To measure group/social identity, we assessed the caregiver's feeling of a sense of cohesion and leadership in a health mothers' group (HMG), and to measure the construct of organizational commitment, we assessed a mother's active participation in an HMG. The e*nvironmental context and resources* domain included two constructs: receiving breastfeeding counseling in the first hour (resources), and access to a home garden (resources). The domain of *emotion* was captured using the Patient Health Questionnaire (PHQ)-9 which assessed the experience of depressive symptoms.[88]

Table 3.1: Definitions of TDF independent variables used in bivariate and multivariable models

TDF domain/ construct	Definition	Measurement	Model specifications Predictor in regression with CF outcomes	 Predictor in regression with EBF outcome
Knowledge				
Knowledge: breastfeeding	Knowledge of exclusive breastfeeding, knowledge of exclusive breastfeeding to six months, timely initiation of breastfeeding, feed colostrum to baby	Score from 0-4		**X**
Knowledge: complementary feeding	Correct knowledge of timely initiation of complementary feeding	Binary (Yes/No)	**X**	
Knowledge: advantages of homestead gardening	Knowledge that homestead gardening can improve diet quality	Binary (Yes/No)	**X**	
Skills				
Skills: responsive feeding with a fussy child	Correct practice of feeding child when fussy	Binary (Yes/No)	**X**	**X**
Competence: feeding a child with low appetite	Correct practice of feeding child with low appetite	Binary (Yes/No)	**X**	**X**
Beliefs about capabilities				
Self-confidence	Certainty in ability to accomplish difficult tasks	Binary (Yes/No)	**X**	**X**
Empowerment	Has control over feeding children	Ordinal (little to no input, input into some decisions, input into most or all decisions)	**X**	**X**
Self-efficacy	Self-efficacy score	Ordinal (low self-efficacy, below average self-efficacy, average self-efficacy, above average self-efficacy, high self-efficacy)	**X**	**X**
Behavioral regulation				
Barriers: difficulty with breastfeeding	Experienced difficulties when breastfeeding	Binary (Yes/No)		**X**
Barriers: difficulty with feeding complementary foods	Experience difficulties when feeding solid/semi solid foods	Binary (Yes/No)	**X**	

Social influences				
Social support	Receives support for feeding semi-solid or solid foods from other family member(s)	Binary (Yes/No)	**X**	
Social/ professional role and identity				
Group/social identity	Feels a sense of cohesion and leadership in HMG	Ordinal (Not at all, small extent, medium extent, large extent)	**X**	**X**
Organizational commitment	Active member in HMG	Binary (Yes/No)	**X**	**X**
Environmental context and resources				
Resources: breastfeeding counseling	Received counseling for breastfeeding in the first hour	Binary (Yes/No)		**X**
Resources: accessible home garden	Homestead garden for food production within 10-minute walk from home	Binary (Yes/No)	**X**	**X**
Emotion				
Anxiety/depression	Experiences depressive symptoms using Patient Health Questionnaire-9	Binary (Yes/No)	**X**	**X**

Abbreviations: TDF=Theoretical Domains Framework, CF=complementary feeding, EBC=exclusive breastfeeding, HMG=Health Mothers Group

All TDF covariates were binary except self-efficacy and leadership and cohesion in HMG. All retrospectively identified TDF constructs were used as independent variables in the analysis. Self-efficacy was measured on a scale representing low, below average, average, above average, and high self-efficacy. Leadership and cohesion in HMG were measured through the question "To what extend do you feel like you can influence decisions in the health mothers group?" on a scale if the respondent agreed not at all, small extent, medium extent, or large extent. TDF domains included in models differed by outcome variable since some questions only pertained to breastfeeding or complementary feeding. For example, the social influences domain was included as an independent variable in assessing predictors of MDD, dietary diversity score (DDS), and timely introduction of complementary foods since the question asked: "Who usually

feeds the child semi-solid or solid food?" and was not relevant to breastfeeding and thus was not assessed in regressions with exclusive breastfeeding as an outcome (Table 3.1).

We tested the relationship between TDF behavioral determinants and IYCF practices for effect modification based on caregiver and FCHV interactions. Respondents interacted with an FCHV if they reported meeting at least once with an FCHV in the last six months.

Demographic covariates identified *a priori* through the literature were included as potential confounders in regression models. These included maternal characteristics (age at first pregnancy), child characteristics (sex), and household characteristics (caste/ethnicity, wealth, agro-ecological zone). Caste used three categories: lower caste (including Dalit, Muslim, and disadvantaged Janjati), relatively advantaged (i.e. Newar, Gurung/Thakali, non-Dalit terai caste) and upper (Brahmin and Chhetri).[41,46] The same measure of wealth used in the Nepal Demographic and Health survey was used in this analysis.[45] Agro-ecological zone was categorized as plains, mountainous or hill.

3.3.4 Data analysis

Descriptive statistics for independent, TDF constructs, and demographic variables were presented including means (standard deviations) for continuous variables, and percentages (95% CI) for categorical variables by survey year. To obtain these point estimates, we used the *survey* package in R using finite population corrections at each sampling level to calculate survey weights.[89] We applied these survey weights to obtain representative estimates for the 42 districts as sample weights, since not considering survey weights can produce biased point estimates.[90–92] Bivariate analyses measuring associations between all independent TDF-derived variables and IYCF indicators were presented using Poisson regression. To check for multicollinearity between

covariates, we assessed the variance inflation factor (VIF) and tolerance for all significant covariates from bivariate analysis. Multicollinearity can inflate type II error and variance and introduces bias in regression estimates.[48,49] Variables with VIF>4 were removed from the analysis or with tolerance levels of <0.25 as an indication of multicollinearity. Then, variables found to be significantly associated with each of the IYCF indicators at $p < 0.10$ were incorporated into multivariable Poisson linear mixed effects models using cluster robust sandwich estimators to estimate prevalence ratios (PR) for exclusive breastfeeding, reaching MDD, DDS, and timely introduction of solid/semi-solid foods.[93] Demographic characteristics identified as potential confounders were included as control variables in multivariate Poisson regression models.[41] Poisson linear regression can be used as an accurate estimate of prevalence ratios using robust standard error adjustments in cross-sectional surveys.[37] If robust standard errors are used in regression modeling of complex surveys, sample weights may be omitted since conclusions are similar if sample weights are used or not.[40] Thus, we used unweighted Poisson regression models to improve precision of estimates. Outputs from the Poisson regressions provided prevalence ratios, 95% confidence intervals, and p-values. In addition, we tested meeting with an FCHV for effect modification to understand whether the strength of association was different depending on whether caregivers interacted with FCHVs. Only the associations found to be significant through multivariable analysis were tested for effect modification. Significance testing was at $p < 0.05$ level. We analyzed complete cases in descriptive analysis and regression modeling. All analyses were conducted in R version 4.2.2. Ethical approval was obtained from the Nepal Health Research Council to collect data used in this analysis.

3.4 RESULTS

Most respondents lived in hill zones (56.2%), while 12.5% lived in mountain areas (Table 3.2). Most mothers were from socially excluded castes (52.9%), reflecting the SII strategy to target disadvantaged groups with their program. More male children were included in the sample compared to females (55.6% vs. 44.4%, respectively). Knowledge levels differed by topic. Mothers had a breastfeeding knowledge score of 2.8 out of 4, while most had good knowledge of correct complementary feeding practice (92.9%) and of home gardening (75.4%). The majority of mothers had responsive feeding skills when a child became fussy or refused to eat (78.9%) though slightly less than half (47.7%) had skills to feed a child with no appetite. Caregivers felt empowered to make decisions about feeding their children in their households and almost three quarters (73.7%) of caregivers were self-confident that they could accomplish difficult tasks.

In terms of self-efficacy, 46.8% scored above average or higher on the self-efficacy scale. Less than 20% of caregivers faced difficulties with feeding, either with breastfeeding or feeding complementary foods to their child. Only 9% of mothers received support from their family members to feed complementary foods. Breastfeeding counseling was offered within the first hour of delivery for 86.4% of mothers in 2019 compared to 71% in 2017. For IYCF practices, 90.7% of mothers practiced timely introduction of complementary foods, while 52.9% of children met minimum dietary diversity with an average DDS score of 3.4. The prevalence of exclusive breastfeeding was lowest in 2022, but on average 63.6% of children less than 6 months were exclusively breastfed.

Table 3.2: Demographic characteristics, Theoretical Domains Framework constructs, and outcomes by year, Suaahara II

	2017 (N=3642) n (%)*	**2018 (N=3648)** n (%)*	**2019 (N=3648)** n (%)*	**2022 (N=3648)** n (%)*	**Pooled data (N=14586)** n (%)*
Demographic characteristics					
Ecological zone, n (%)					
Mountain	455 (12.5%)	456 (12.5%)	456 (12.5%)	456 (12.5%)	1823 (12.5%)
Hill	2047 (56.2%)	2052 (56.3%)	2052 (56.3%)	2052 (56.3%)	8203 (56.2%)
Terai	1140 (31.3%)	1140 (31.3%)	1140 (31.3%)	1140 (31.3%)	4560 (31.3%)
Wealth quintile, n (%)					
Lowest	790 (21.7%)	625 (17.1%)	591 (16.2%)	358 (9.8%)	2364 (16.2%)
2nd lowest	1043 (28.6%)	903 (24.8%)	824 (22.6%)	825 (22.6%)	3595 (24.6%)
Middle	845 (23.2%)	909 (24.9%)	801 (22.0%)	907 (24.9%)	3462 (23.7%)
2nd highest	740 (20.3%)	908 (24.9%)	1076 (29.5%)	1143 (31.3%)	3867 (26.5%)
Highest	224 (6.2%)	303 (8.3%)	356 (9.8%)	415 (11.4%)	1298 (8.9%)
Caste, n (%)					
Socially excluded	1805 (49.6%)	1924 (52.7%)	1974 (54.1%)	2011 (55.1%)	7714 (52.9%)
Brahmin	1432 (39.3%)	1415 (38.8%)	1353 (37.1%)	1317 (36.1%)	5517 (37.8%)
Others	405 (11.1%)	309 (8.5%)	321 (8.8%)	320 (8.8%)	1355 (9.3%)
Mother's age, Mean (SD)	26.2 (5.50)	25.9 (5.39)	26.0 (5.33)	26.5 (5.40)	26.2 (5.41)
Age at first pregnancy, Mean (SD)	19.5 (2.98)	19.5 (2.95)	19.7 (2.95)	20.0 (3.38)	19.7 (3.08)
Child's age, Mean (SD)	24.8 (16.0)	24.6 (16.2)	25.4 (16.3)	25.7 (16.2)	25.1 (16.2)
Child sex					
Male	2023 (55.5%)	1995 (54.7%)	2078 (57.0%)	2016 (55.3%)	8112 (55.6%)
Female	1619 (44.5%)	1653 (45.3%)	1570 (43.0%)	1632 (44.7%)	6474 (44.4%)
TDF domains (constructs)					
Knowledge					
Breastfeeding score#, Mean (SD)	2.70 (0.81)	2.82 (0.76)	2.92 (0.76)	2.67 (0.75)	2.78 (0.78)

Complementary foods should be introduced at 6 months	3364 (92.7%)	3389 (93.1%)	3413 (93.7%)	3356 (92.2%)	13522 (92.9%)
Home gardening can improve diet quality	2065 (56.7%)	3081 (84.5%)	3101 (85.0%)	NA	8247 (75.4%)
Skills					
Feeding a fussy child	2874 (78.9%)	NA	NA	NA	2874 (78.9%)
Feeding a child with no appetite	1736 (47.7%)	NA	NA	NA	1736 (47.7%)
Beliefs about capabilities					
Self confidence	2604 (71.6%)	2677 (73.4%)	2774 (76.1%)	NA	8055 (73.7%)
Empowerment	3358 (92.2%)	3426 (93.9%)	3471 (95.1%)	NA	10255 (93.8%)
Self-efficacy					
Low self-efficacy	211 (5.8%)	244 (6.7%)	174 (4.8%)	NA	629 (5.8%)
Below average self-efficacy	589 (16.2%)	589 (16.2%)	521 (14.3%)	NA	1699 (15.5%)
Average self-efficacy	1271 (34.9%)	1176 (32.2%)	1033 (28.3%)	NA	3480 (31.8%)
Above average self-efficacy	1118 (30.7%)	1136 (31.1%)	1224 (33.6%)	NA	3478 (31.8%)
High self-efficacy	449 (12.3%)	502 (13.8%)	694 (19.0%)	NA	1645 (15.0%)
Behavioral regulation					
Difficulties while breastfeeding (n=1843)	341 (18.5%)	NA	NA	NA	341 (18.5%)
Difficulties while feeding complementary foods (n=1438)	138 (9.6%)	NA	NA	NA	138 (9.6%)
Social influences					
Support for feeding complementary foods from family	256 (11.7%)	129 (5.9%)	NA	NA	385 (8.8%)
Social professional role and identity					
Leadership and cohesion in HMG					
Not at all	147 (14.5%)	NA	NA	NA	147 (14.5%)
Small extent	531 (52.5%)	NA	NA	NA	531 (52.5%)
Medium extent	239 (23.6%)	NA	NA	NA	239 (23.6%)
Large extent	94 (9.3%)	NA	NA	NA	94 (9.3%)
Active member in HMG	1011 (43.0%)	994 (37.7%)	905 (30.0%)	NA	2910 (36.3%)
Environmental context and resources					
Resources: Received breastfeeding counseling within first hour	1305 (71.0%)	1601 (84.3%)	1561 (86.4%)	NA	4467 (80.6%)
Resources: Accessible home garden	2767 (76.0%)	3089 (84.7%)	948 (89.3%)	2990 (82.0%)	9794 (81.6%)

Emotion					
Experience depressive symptoms	1908 (52.4%)	NA	NA	NA	1908 (52.4%)
IYCF indicators					
Minimum dietary diversity - child	1727 (47.7%)	1921 (52.7%)	1999 (54.8%)	2057 (56.4%)	7704 (52.9%)
Timely introduction of complementary foods	1238 (91.2%)	1315 (90.8%)	1267 (91.5%)	1245 (89.2%)	5065 (90.7%)
Exclusive breastfeeding (0-5.9 months)	286 (62.9%)	296 (65.8%)	297 (68.9%)	233 (56.6%)	1112 (63.6%)
Dietary Diversity score for children (6-59 months), Mean (SD)	3.18 (1.53)	3.35 (1.58)	3.54 (1.63)	3.47 (1.59)	3.35 (1.58)

Abbreviations: NA = covariate not measured in respective year, TDF=Theoretical Domains Framework, IYCF=Infant and Young Child Feeding; SD=standard deviation; HMG=health mothers group
*unless noted as mean (SD)
#Breastfeeding scores ranged from 0-4

Variables identified through bivariate analysis with MDD and DDS as outcomes had VIF between 1.02-1.64 and tolerance ranged from 0.61-0.98, suggesting no multicollinearity between covariates.

While possessing responsive feeding skills with a fussy child was significantly associated with exclusive breastfeeding in univariate analysis, after adjusting for potential confounders this association no longer remained significant (p=0.091) (Table 3.3).

Table 3.3: Associations between TDF constructs and exclusive breastfeeding, *Suaahara* II

TDF domains (constructs)	**Unadjusted** Exclusive breastfeeding, PR (95% CI)	***p***	**Adjusted** Exclusive breastfeeding, PR (95% CI)	***p***
Knowledge				
Breastfeeding score, Mean (SD)	1.06 (0.98 – 1.15)	0.13	-	-
Skills				
Feeding a fussy child	0.8 (0.63 – 1.00)	**0.05**	0.82 (0.65 – 1.03)	0.091
Feeding a child with low appetite	0.87 (0.66 – 1.13)	0.29	-	-
Beliefs about capabilities				
Self confidence	0.96 (0.83 – 1.11)	0.60	-	-
Empowerment	0.97 (0.75 – 1.25)	0.79	-	-
Self efficacy				
Low self efficacy (ref)	1		-	-
Below average self-efficacy	1.04 (0.75 – 1.45)	0.81	-	-
Average self-efficacy	1.05 (0.77 – 1.43)	0.77	-	-
Above average self-efficacy	1.05 (0.77 – 1.43)	0.75	-	-
High self-efficacy	1.07 (0.77 – 1.50)	0.68	-	-
Behavioral regulation				
Difficulties while breastfeeding	0.8 (0.59 – 1.09)	0.16	-	-
Social professional role and identity				
Leadership and cohesion in HMG				
Not at all (ref)	1		-	-
Small extent	1.43 (0.71 – 2.88)	0.31	-	-
Medium extent	1.52 (0.69 – 3.36)	0.30	-	-
Large extent	1.14 (0.36 – 3.65)	0.82	-	-
Active member in HMG	1.03 (0.88 – 1.22)	0.69	-	-
Environmental context and resources				
Received breastfeeding counseling within first hour	0.99 (0.84 – 1.18)	0.95	-	-

Emotion				
Depressive symptoms	0.85 (0.67 – 1.07)	0.17	-	-

Abbreviations: SD=standard deviation, PR=prevalence ratio, CI=confidence interval, SD=standard deviation, HMG=health mothers group

TDF domains of skills and social professional role and identity were significantly associated with reaching MDD and dietary diversity (Table 3.4). Caregivers reporting that they used responsive feeding with a child who refuses or fusses over eating had 31% higher prevalence of having a child that reached MDD (p=0.001) and was positively associated with a higher dietary diversity score [aPR: 1.25 (95% CI: 1.17-1.33)]. Caregivers with skills responding to a child with a low appetite over multiple days had 21% higher prevalence of having a child that reached MDD (p=0.002). In addition, caregivers who were active members in FCHV-facilitated community groups were 19% more likely to have a child who reached MDD (p=0.003) and higher DDS scores [aPR: 1.19 (95% CI: 1.06 – 1.34)]. Correct knowledge of complementary feeding was also associated with timely introduction of semi solid or solid foods (aPR:1.26, 95% CI: 1.12-1.41) (Table 3.5).

Table 3.4: Associations between TDF constructs and complementary feeding indicators, *Suaahara* II

	Unadjusted				*Adjusted*			
TDF domains (constructs)	**MDD, PR (95% CI)**	***p***	**DDS, PR (95% CI)**	***p***	**MDD, PR (95% CI)**	***p***	**DDS, PR (95% CI)**	***p***
Knowledge								
Complementary foods should be introduced at 6 months	1.05 (0.96 – 1.15)	0.245	1 (0.96 – 1.03)	0.798	-	-	-	-
Home gardening can improve diet quality	1.16 (1.09 – 1.24)	**<0.001**	1.08 (1.05 – 1.11)	**<0.001**	1.11 (0.98 – 1.25)	0.099	1.03 (0.99 – 1.08)	0.108
Skills								
Feeding a fussy child	1.42 (1.25 – 1.62)	**<0.001**	1.29 (1.23 – 1.36)	**<0.001**	1.30 (1.10 – 1.53)	**0.001**	1.25 (1.17 – 1.33)	**<0.001**
Feeding a child with low appetite	1.3 (1.18 – 1.43)	**<0.001**	1.19 (1.14 – 1.23)	**<0.001**	1.21 (1.07 – 1.36)	**0.002**	1.13 (1.08 – 1.18)	**<0.001**
Beliefs about capabilities								
Self confidence	1.08 (1.02 – 1.15)	**0.01**	1.05 (1.03 – 1.08)	**<0.001**	0.97 (0.83 – 1.13)	0.61	1.01 (0.95 – 1.07)	0.84
Empowerment	0.97 (0.87 – 1.08)	0.61	1.01 (0.96 – 1.05)	0.745	-	-	-	-
Self efficacy								
Low self efficacy (ref)	1		1		1		1	
Below average	1.17 (1.01 – 1.34)	**0.03**	1.02 (0.96 – 1.08)	0.536	0.90 (0.66 – 1.21)	0.526	0.98 (0.87 – 1.10)	0.746
Average	1.25 (1.10 – 1.43)	**0.00**	1.05 (1.00 – 1.11)	0.062	0.94 (0.70 – 1.27)	0.821	1.03 (0.92 – 1.16)	0.628
Above average	1.32 (1.15 – 1.50)	**<0.001**	1.08 (1.02 – 1.14)	0.01	0.99 (0.73 – 1.35)	0.906	1.02 (0.91 – 1.16)	0.702
High self efficacy	1.38 (1.20 – 1.59)	**<0.001**	1.12 (1.05 – 1.19)	**<0.001**	0.94 (0.67 – 1.33)	0.896	1.02 (0.89 – 1.16)	0.808
Social influences								
Support for feeding complementary foods from family	1.04 (0.90 – 1.19)	0.62	1.02 (0.97 - 1.08)	0.41	-	-	-	**-**

Social professional role and identity								
Leadership and cohesion in HMG								
Not at all (ref)	1		1					
Small extent	1.19 (0.91 – 1.54)	0.20	1.11 (1.00 – 1.23)	0.054	-	-	1.07 (0.97 – 1.20)	0.184
Medium extent	1.25 (0.94 – 1.66)	0.13	1.14 (1.02 – 1.28)	**0.026**	-	-	1.1 (0.98 – 1.24)	0.106
Large extent	1.34 (0.95 – 1.89)	0.10	1.16 (1.01 – 1.34)	**0.035**	-	-	1.09 (0.94 – 1.26)	0.261
Active member in HMG	1.2 (1.13 – 1.27)	**<0.001**	1.09 (1.06 – 1.12)	<0.001	1.19 (1.06 – 1.34)	**0.004**	1.08 (1.03 – 1.13)	**0.001**
Environmental context and resources								
Accessible home garden	1.13 (1.06 – 1.21)	**<0.001**	1.05 (1.03 – 1.08)	**<0.001**	0.99 (0.86 – 1.14)	0.881	1.02 (0.96 – 1.08)	0.468
Emotion								
Depressive symptoms	0.97 (0.88 – 1.07)	0.56	1.01 (0.97 – 1.04)	0.77	-	-	-	-

Poisson mixed effects models with robust standard errors and clusters (sub-wards) as random intercept. Adjusted models controlled for confounders: wealth quintile, caste, agro-ecological zone, maternal age at first pregnancy, child sex, residency, maternal education level, and survey year. Abbreviations: TDF=Theoretical domains framework, PR=prevalence ratio, CI=confidence interval, HMG=health mothers group

Table 3.5: Associations between TDF constructs and timely introduction of semi-solid/solid foods, *Suaahara* II

TDF domains (constructs)	*Unadjusted* MDD, PR (95% CI)	*Unadjusted* p	*Adjusted* MDD, PR (95% CI)	*Adjusted* p
Knowledge				
Complementary foods should be introduced at 6 months	1.26 (1.13 – 1.41)	**<0.001**	1.26 (1.12 - 1.41)	**<0.001**
Home gardening can improve diet quality	1.01 (0.93 – 1.08)	0.868	-	-
Skills				
Feeding a fussy child	0.99 (0.84 – 1.17)	0.90	-	-
Feeding a child with low appetite	0.99 (0.89 – 1.11)	0.88	-	-
Beliefs about capabilities				
Self confidence	0.99 (0.92 – 1.07)	0.84	-	-
Empowerment	1.04 (0.91 – 1.18)	0.59	-	-
Self efficacy				
Low self efficacy (ref)	1		-	-
Below average	1.05 (0.90 – 1.22)	0.56	-	-
Average	1.02 (0.89 – 1.18)	0.74	-	-
Above average	1.03 (0.89 – 1.18)	0.72	-	-
High self efficacy	1.03 (0.88 – 1.20)	0.75	-	-
Social influences				
Support for feeding complementary foods from family	0.96 (0.83 – 1.11)	0.563	-	-
Social professional role and identity				
Leadership and cohesion in HMG				
Not at all (ref)	1		-	-
Small extent	0.96 (0.69 – 1.33)	0.80	-	-
Medium extent	0.98 (0.69 – 1.40)	0.92	-	-
Large extent	0.93 (0.58 – 1.49)	0.76	-	-
Active member in HMG	1.01 (0.93 – 1.09)	0.86	-	-
Environmental context and resources				
Accessible home garden	1 (0.92 – 1.08)	0.945	-	-
Emotion				
Depressive symptoms	0.97 (0.87 – 1.09)	0.65	-	-

Poisson mixed effects models with robust standard errors and clusters (sub-wards) as random intercept. Adjusted models controlled for confounders: wealth quintile, caste, agro-ecological zone, maternal age at first pregnancy, child sex, residency, maternal education level, and survey year. Abbreviations: TDF=Theoretical domains framework, PR=prevalence ratio, CI=confidence interval, HMG=health mothers

Interaction with FCHVs modified the relationship between skills in responsive feeding and dietary diversity score (Table 3.6). The prevalence of having skills to feed a fussy child and child DDS scores were higher if mothers met with an FCHV in the past six months (aPR=1.34 (95% CI: 1.26, 1.42) compared to those who did not meet with FCHVs in the last six months (aPR=1.18 (95% CI: 1.09, 1.27). The measure of effect modification was -0.08 on an additive scale and 1.14 on a multiplicative scale, suggesting that the joint effect of responsive feeding skills and meeting with an FCHV together was greater than the product of the effect of possessing responsive feeding skills alone and meeting with FCHVs alone with DDS, demonstrating effect modification on the multiplicative scale. FCHV interactions did not modify other relationships between TDF constructs and dietary outcomes.

Table 3.6: Modification of association between having skills to feed a fussy child (responsive feeding) on child dietary diversity score by FCHV interaction

	No skills feeding fussy child **aPR (95% CI)**	Has skills to feed fussy child **aPR (95% CI)**	**aPR (95% CI) for DDS within strata of FCHV interaction**
No FCHV interaction	Ref	1.18 (1.09, 1.27); p<0.001	1.18 (1.09, 1.27); p<0.001
FCHV interaction	0.89 (0.81, 0.97); p=0.010	1.00 (0.96, 1.05); p=0.850	1.34 (1.26, 1.42); p=0.014

Measure of effect modification on an additive scale: RERI = 1.00-0.9-1.18+1 = -0.08

Measure of effect modification on a multiplicative scale: 1.34/1.18 = 1.14

Adjusted for wealth quintile, caste, agro-ecological zone, maternal age at first pregnancy, child sex, residency, maternal education level, and survey year; Abbreviations: PR=prevalence ratio, CI=confidence interval, FCHV= female community health volunteer

3.5 DISCUSSION

This study leveraged available data from four *Suaahara* II annual monitoring surveys to identify behavioral determinants of key breastfeeding and complementary feeding outcomes. Knowledge, skills, and social professional role and identity were associated with complementary feeding practices. Specifically, skills around practicing nurturing care, responsive feeding, and active participation in FCHV-facilitated community groups were associated with child MDD and DDS, and knowledge of timely initiation of foods at six months was associated with timely introduction of semi-solid or solid foods. Meeting at least once with an FCHV in the last six months modified the associations between responsive feeding skills and child DDS.

These findings support existing literature on the connection between nurturing care on child growth and development.[94] Nurturing care posits that a safe, fun, positive environment for children has implications on growth, productivity, and promotes health. A component of nurturing care includes responsive feeding practices that places importance on feeding a child when they are hungry, listening to child hunger cues and establishing a two-way connection between caregiver and child.[95,96] Responsive feeding is especially important for low birthweight babies or during episodes of child sickness.[97] Studies conducted in Peru, Nicaragua, and Indonesia, demonstrated responsive feeding was positively associated with achieving MDD,[98] with evidence that responsive feeding was associated with intake of complementary foods.[99] As a result, responsive feeding has been incorporated in the World Health Organization and the UN Children's Fund (UNICEF) global guidance on IYCF practice.[34,36,100,101] In addition to responsive feeding, active membership in an FCHV-led health mothers group or community group was associated with greater consumption of a diverse diet for young children. This corroborates findings from Kenya demonstrating that monthly participation in community groups

was associated with higher child DDS scores.[102] That study showed that dietary diversity increased with greater participation intensity, which suggests that nutrition messages shared in community groups had a demonstrable improvement on dietary intake for children. In our study, active participation in community groups was also strongly associated with reaching MDD and DDS showing the benefits of FCHV and peer support on improved dietary diversity among children.

Caregiver knowledge was strongly associated with timely introduction of complementary foods but was not associated with child consumption of a diverse diet. Mixed evidence exists to support the link between knowledge and practice of complementary feeding behaviors.[103,104] While knowledge may be a factor in the introduction of complementary foods, it may not be sufficient to reach dietary adequacy after foods are introduced, supporting studies showing the disconnect between knowledge and optimal diet and feeding practice.[105,106] Instead, community and facility-based interventions that go beyond simply increasing knowledge of IYCF could be effective to improve IYCF practices. Facility-based interventions could include directed skills-based trainings to improve counseling provision for health workers.[107,108] At a community or household level, optimal child feeding practices are dependent on multiple factors including available resources and caregiver time obligations.[109–111] Interventions should not only target increasing knowledge, but focus on strengthening caregiver skills and establishing an enabling environment necessary to support the sustained practice of optimal IYC behaviors.

Interacting with FCHVs resulted in stronger associations between skills in responsive feeding and dietary diversity. For caregivers that had not met with an FCHV in the last six months, responsive feeding skills had a weaker association with DDS. The difference in strength of association may in part be due to the intensity of FCHV counseling and peer support. FCHVs are

trained to increase the reach of government health and nutrition extension with community-level behavior change communication activities. They provide age-appropriate behavior change communication counseling through group and home-based support to families in the first 1000 days. FCHVs have multiple touch points with caregivers through home visits, health mothers' groups, and community-wide health events. These interactions with FCHVs and other community health volunteers has been shown to improve child feeding in multiple contexts, and are an integral component to the success of Nepal's community health strategy.[112–115]

In this study, challenges with infant and child feeding were not associated with achieving feeding outcomes, which may have been affected by sample size as these indicators were collected in only one survey year. Beliefs about capabilities, such as self-efficacy and self-confidence were significant in bivariate analyses but became non-significant after controlling for demographic covariates. Maternal self-efficacy measures captured the general ability to accomplish goals and overcome obstacles and did not specifically ask about maternal self-efficacy related to child feeding practices. In future studies, questions could reflect self-efficacy specifically for complementary feeding to corroborate previous studies documenting the role of maternal self-efficacy for complementary feeding on feeding green leafy vegetables to a child.[116]

This study retrospectively applied the Theoretical Domains Framework to identify factors associated with caregiver practice of exclusive breastfeeding, minimum dietary diversity for children, and timely introduction of complementary foods. The TDF is used to assess a broad range of factors distilled from 33 behavior change theories within 128 theoretical constructs.[83,84] This framework has been used to understand barriers and facilitators for a wide range of behaviors including electronic aid use,[117] liver disease management,[118] participation in clinical trials,[119] and nutrition behaviors in pre-pregnancy.[120] Though the TDF has been used in a limited

number of quantitative studies[121,122], it has largely been applied to assessments using qualitative methods which limit generalizability of findings.[83,123,124] To our knowledge, this is the first application of the TDF to understand determinants of caregiver practice of key infant and young child feeding behaviors expanding the use of the TDF to understand factors affecting nutrition behaviors in the critical 1000-day window of growth. Applying this integrative framework in a quantitative manner offers a novel way of understanding determinants of caregiver practice of exclusive breastfeeding and complementary feeding behaviors facilitating inference over a larger population.

3.5.1 Limitations

This study had several limitations. First, retrospectively identifying TDF domains using secondary data limited our ability to cover all domains of the TDF. The study included constructs that could be mapped using existing survey items, which covered 8 of the 12 TDF domains. This limitation reflects the reality of using such a comprehensive framework that integrates concepts from multiple behavioral theories. Most studies using the TDF apply only a subset of the domains since often it is difficult to include all domains in one study.[121] Future applications of the TDF to study IYCF behaviors could include prospective data collection to assess additional behavioral determinants of IYCF behavior. Future research assessing behavioral determinants of intention, reinforcement, goals, and optimism to capture associations with breastfeeding and dietary diversity could elucidate further factors that influence uptake of these key IYCF behaviors. Secondly, the comprehensiveness of measurement of behavioral predictors varied depending on questions included in the surveys. Some TDF constructs were measured more fully than other constructs in this analysis. For example, four survey questions were used to construct the breastfeeding knowledge score. The breastfeeding knowledge construct may be more

comprehensively measured than the single question measuring social influences for example. Though this is a limitation of using secondary data, we have confidence that the questions included in the survey adequately capture either full or partial definitions of the identified constructs. Further work could incorporate a broader range of questions to assess each construct more comprehensively. Thirdly, we had substantial missing data for TDF predictors especially for the 2018, 2019, and 2022 surveys which asked fewer questions than the 2017 dataset. The focus of the 2018-2019 monitoring surveys was to collect data on demographic characteristics, knowledge, and practices with less emphasis on group membership, IYCF skills, and challenges with feeding. In response to this data constraint, we conducted complete case analysis using existing data across the four survey years adding year as a covariate in the analysis. In our study, data were assumed to be missing completely at random. For situations where data are missing completely at random, complete case analysis yields unbiased estimates and achieves similar or better precision than using multiple imputation methods.[125] Thus, there is minimal bias due to missing data. Fourth, our analysis relied on self-reported dietary recall to construct dietary outcomes. Self-reported data may introduce recall bias and social desirability bias. However, we restricted the recall period to 24-hours and used a standardized, robustly tested dietary instrument used in Demographic and Health Surveys across various countries including Nepal to minimize bias.[1,50]

Despite these limitations, the study findings can be used in future program design to target behavioral determinants associated with child dietary outcomes in Nepal. Responsive feeding skills and active participation in community health groups have a significant positive association with optimal complementary feeding practice. Interactions with FCHVs can also improve dietary

outcomes for children. Participation in community groups and meeting with health volunteers can have substantial impacts on child dietary outcomes.

3.6 Conclusion

We identified behavioral determinants associated with key infant and young child feeding practices among caregivers with young children in Nepal and the role of FCHV meetings as an effect modifier of these relationships. We applied a novel use of the TDF to identify behavioral factors influencing child dietary intake. These study results can be used in designing and targeting community and facility-based nutrition programs in Nepal to improve complementary feeding practices.

Chapter 4. Costs of a complex scaled-up multi-sectoral nutrition program in Nepal

4.1 ABSTRACT

Introduction: Limited evidence exists on the costs of scaled-up multi-sectoral nutrition programs. Such evidence is crucial to assess intervention value and affordability. Evidence is also lacking on the opportunity costs of implementers and participants engaging in community-level interventions. We address this gap by estimating the full financial and economic costs of the USAID funded *Suaahara* II (SII) program, a large multi-sectoral nutrition program in Nepal (2016-2023).

Methods: We applied a standardized mixed methods costing approach to estimate total and unit costs over a 3.7-year implementation period. Financial expenditure data from national and subnational levels were combined with economic cost estimates assessed using in-depth interviews and focus group discussions with staff, volunteers, community members, and government partners in four representative districts.

Results: The average annual total cost was US$908,948 per district, with economic costs accounting for 47% of the costs. The unit cost was US$132 per individual program beneficiary (mother in first 1000 days post-conception) reached. Costs ranged from US$152 (mountain-type district) to US$118 (plains) per 1000-day mother participant. Personnel (63%) were the largest input cost driver, followed by supplies (11%). Community events (29%) and household counseling visits (17%) were the largest activity cost drivers. Volunteer cadres contributed significant time to the program, with female community health volunteers spending a substantial amount of time (27 hours per month) on SII activities.

Discussion: Multi-sectoral nutrition programs can be costly especially when taking into consideration volunteer and participant opportunity costs. This study provides much-needed evidence of the costs of scaled-up national-level nutrition programs for future comparison against benefits.

4.2 INTRODUCTION

Nepal has made tremendous progress over the last few decades on many maternal and child health and nutrition indicators.[126] Commitment to nutrition has been demonstrated by the government's early engagement in the Scaling Up Nutrition global community and its adoption of a Multisector Nutrition Plan (MSNP I 2013-2017 and MSNP II 2018-2022).[127,128] The MSNP includes both nutrition-specific and nutrition-sensitive strategies, and is currently being implemented throughout the country, including by local leaders at district and municipality levels. Since the early 1980s, Nepal has relied on a cadre of more than 50,000 Female Community Health Volunteers (FCHVs) to reach communities and households, as much of the population is geographically disconnected from health facilities.[129] FCHVs have played an important role in delivering community-based health services across the country and have been critical to achieve nutrition targets. Recent investments have leveraged the existing FCHV network and government health programs to deliver quality health and nutrition programs.

Suaahara II (2016-2023) (SII), a USAID-funded program, was led by Helen Keller International (HKI), along with seven national and international non-governmental organizations (iNGO) and more than 35 Nepali district-level NGO partners. SII supported Nepal's MSNP, using FCHVs as a central delivery strategy,[9] and built off of gains from *Suaahara* I (2011-2016) and existing government programs. SII's expanded multisectoral nutrition strategies included interventions in agriculture, WASH, health, nutrition, gender, and governance in 42 of Nepal's 77 districts, with an aim to reduce maternal and child undernutrition (Appendix Figure 1).

Program components included multi-sectoral social behavior change communication (SBCC), as well as interventions to strengthen facility and community level health and nutrition services; facilities and environments for water, sanitation and hygiene; and governance at local, district

and national level. Targeting households in the first 1000-days of life, SII explicitly targeted disadvantaged households with an enhanced set of interventions including the addition of homestead food production (Appendix, Figure 2). A detailed list of government partners, NGO staff, frontline workers, including community volunteers and their roles in implementing this project is found in Appendix Table 1.

The large scope of this program – both in terms of sector and geography – provides a unique opportunity for global learning about costs of a multi-sectoral nutrition program implemented at scale.[130] Multi-sectoral nutrition programs have complex designs involving multiple partners and activities across sectors, making the comparison of costs challenging.[131,132] To make the case for further investment in multi-sectoral nutrition programs, greater understanding of their costs is needed.[133] Evidence on costs of complex multi-sectoral programs remains limited, although donors are increasingly requiring or recommending implementers to track and report costs.[133–135] An understanding of the major cost drivers of SII – by input, activity, and sector - could inform resource allocation for design and implementation decisions and provide budget estimates across relevant sectors for further scale-up.

Complex nutrition programs like SII require a mix of implementing partners, including volunteers, and rely on the engagement of targeted participants and their communities to improve nutrition outcomes. Capturing economic costs, therefore, is essential for assessing full resource use, providing insights into participants' tradeoffs that can affect program success. Economic costs are opportunity costs of time and out of pocket costs incurred for SII by implementers and community members. Often multi-sectoral programs are designed to engage health and nutrition government officials and frontline volunteers. This analysis estimates the time required by

government workers, volunteers, program participants, and NGO staff, providing important insights to program designers and implementers.

This paper measures the costs of SII, a multi-sectoral program in Nepal that reaches over 2 million direct participants including: (1) estimating the total incremental costs and average cost per output and (2) estimating opportunity costs of individual program participants.

4.3 METHODS

4.3.1 Overall approach

We applied the Strengthening Economic Evaluations in Multisectoral Strategies for Nutrition (SEEMS-Nutrition) standardized costing approach to understand the costs of SII. The SEEMS-Nutrition approach was built on and incorporates best practices from the Global Health Cost Consortium Reference Case to estimate SII total and unit costs.[136] Total SII costs were measured over and above the investments made in *Suaahara* I; we therefore describe the cost estimates as total incremental.[137–140]

We followed four stages of the SEEMS-Nutrition approach. In the first stage we aligned SII intervention components to a standardized multi-sectoral intervention typology inspired by the SUN Compendium of Actions for Nutrition and the nutrition-sensitive value chain (NSV).[141,142] The NSV typology classifies interventions as: 1) increasing supply of nutritious foods, 2) increasing demand for nutritious foods, and 3) strengthening the enabling environment for nutrition.[142] The second stage used the program impact pathway to align program activities and inputs with the NSV typology (Appendix Figure 1). The third stage estimated costs by program

impact pathway to achieve outputs and outcomes. The last stage combined estimates of total incremental costs with program outputs to derive unit costs.

Costs were categorized as standardized SEEMS-Nutrition inputs, activities, NSV typology and sector categories, and as either start-up or recurrent. Table 4.1 shows SII activities mapped to the SEEMS-Nutrition cost categories by activity and NSV typology. Start-up costs included program design, initial trainings, materials development, and program sensitization. Recurrent costs included home visits, community groups and events, field supervision, management, and refresher trainings. Appendix Table 2 describes standard input cost categories.

Table 4.1: SII activities mapped to SEEMS-Nutrition activity and NSV chain typology categories

SEEMS Activity category	SII activities
START UP COSTS	
Materials development	Development of training materials, social and behavior change communication materials, job aids
Training	One time only trainings at all levels for staff, frontline workers, individuals
Program sensitization	Activities related to program sensitization at all levels – national to community level
Program installation	Hiring staff and frontline workers, start-up meetings
Recruitment	Recruitment of staff and volunteers for Suaahara II activities
Planning	Planning activities included in start-up phase
RECURRENT COSTS	
Training (recurrent)	Recurrent or refresher trainings
Management	Project management meetings and activities
Monitoring	Establishing and using data systems for monitoring
Procurement	Procurement of chickens, seeds, agriculture tools, and training materials on health/nutrition, agriculture, health, water/sanitation for distribution to program participants, volunteers, households
Distribution of inputs	Distribution of chickens, seeds, agriculture tools, and training materials to program participants, volunteers, households, communities
Home visits: multi-sectoral interpersonal communication	Home visits conducted by frontline workers and staff for interpersonal communication, as part of Suaahara II social and behavior change
Home visits for enhanced homestead food production	Home visits conducted by frontline workers (Village Model Farmers), and staff to provide technical assistance on agriculture/ homestead food production
Health facility counseling and support	Health and nutrition support provided by the Health Post in Charge and Auxiliary Nurse Midwife at the health facility
Community events and mass media	Community-level food demonstrations, agriculture field days, key life events, mass media campaigns, other community activities
Site supervision	National and sub-national level supervision of implementation and service delivery
Health mothers' groups, adolescent groups, village model farm groups	Activities related to community groups (health mothers' groups, village model farm groups, adolescent groups, etc.)
Microcredit activities	Savings group activities

Marketing support	Activities related to strengthening market linkages
Integration and coordination	Recurrent review and planning meetings across implementing partners and the government, cross cutting activities including supporting gender, equity and social inclusion (GESI) champions
Overhead/indirect costs	Office maintenance, office rent, phone, indirect personnel costs not directly related to above activities.
NSV chain typology category	
Increase demand	Activities designed to increase demand for nutritious foods and quality nutrition-related services, primarily social and behavior change interventions such as household visits, group meetings, key life events, and mass media campaigns
Increase supply	Activities designed to enhance homestead food production and village model farm groups
Enabling environment	Activities enabling increased gender empowerment and government ownership and participation in all activities, focused on local nutrition governance and improved coordination between MSNP stakeholders.

We used mixed methods combining expenditures and micro-costing to estimate the incremental total costs and unit costs of SII for the period July 2016 to March 2020 (3.7 years), which captured implementation costs prior to the onset of the COVID-19 pandemic in Nepal. We estimated both financial costs (expenditures by HKI and sub-grantees) and economic costs. We adopted a societal perspective, estimating costs for donated or shared resources, such as time use and out-of-pocket expenses incurred by government and program frontline volunteers, government partners (e.g., health post staff), and participants (e.g., 1000-day mothers), that were not already covered by SII project financial expenditures.

4.3.2 Study sample

The cost analysis was conducted in a sample of four districts enabling estimation of unit costs in four geographically diverse contexts within Nepal. The districts were purposefully selected for agroecological zone representation: the Terai/plains (Nawalparasi), hills (Bajhang, Dhading), and mountain (Sindhupalchok). Nawalparasi, Bajhang, and Sindhupalchok all had the SI program prior to SII; Dhading did not, and was included to more comprehensively understand start-up

costs. Within each district, we randomly sampled at least one urban and one rural municipality (Appendix Table 3).

4.3.3 Data collection

Financial expenditure data were obtained from HKI accounting systems for all expenses incurred at the national and sub-national level by HKI, including national and international NGO partners, as well as for the local NGOs operating in the four sampled districts. We supplemented financial expenditure data with data collected through in-depth interviews (IDIs) and focus group discussions (FGDs) with SII and local NGO program staff at national and sub-national levels on time and resource use. FGDs were used to estimate time and out-of-pocket expenses from government partners and frontline volunteers who supported SII implementation, but who were not paid by SII, and from program participants.

IDIs and FGDs captured time spent on SII activities and additional out-of-pocket expenses incurred due to participation. A first round of qualitative data collection occurred in Dhading in September 2019, Sindupalchok in January 2020, Nawalparasi in March-April 2020, and Bajhang in July – August 2020. A second round of qualitative data collection occurred in all four districts in December 2021 - February 2022 to increase the sample for government partners, frontline volunteers, and direct program participants. Interviews during the second phase were conducted over the phone due to COVID-19 restrictions on movement, while focus groups were conducted in person.

4.3.4 Outputs

Program outputs were used to estimate unit costs for measuring reach of Suaahara II interventions: (1) the number of 1000-day mothers reached; (2) the combined total of 1000-day mothers and index child under 2 years of age reached (mother-child dyads) (3) the number of 1000-day household members reached; and (4) the total number of households reached by SII interventions. 1000-day household members included grandparents, spouses, and non-index children in the household. Households represented the number of unique households with a 1000-day mother or child targeted by SII in each district. Project outputs (Table 4.4) were recorded as annual averages over the implementation period and provided the denominator for unit cost estimates, described below. Output data on participant and household reach were obtained from SII's monitoring systems and reports.

4.3.5 Cost and time use estimates

Total incremental costs were defined as total incremental financial and economic costs, inclusive of all costs at national and sub-national levels. Unit costs were defined as total incremental costs divided by program outputs per 1000-day mother, 1000-day mother-child dyad, per total participant reached, and per household reached. We present the weighted average annual total incremental and unit costs.

We also presented disaggregated cost data by cost type: economic or financial, by agro-ecological zone, and by when the district joined the program ('new' districts participating in SII compared to 'continuing' districts participating in SI and SII). We explored cost profiles to examine the share of total costs by input, activity, and timing (startup or recurrent). Costs shares were explored by NSV typology and sector to describe resource allocation and distribution of costs necessary to implement SII. To understand community-level contributions, we included

monthly time estimates of participating frontline volunteers, government partners, and 1000-day mothers.

4.3.6 Data analysis

We presented financial and economic costs separately to arrive at total and unit costs of the SII program.

Financial data were analyzed with a standardized SEEMS-Nutrition expenditure analysis Microsoft Excel tool. We populated the tool with financial expense data for international NGO partners and local NGO partners in the four sampled districts. All line items were coded using SEEMS standardized input categories (Appendix Table 2). Time allocation collected from interviews was used to allocate personnel costs to the SEEMS standardized activity, NSV typology, and sector categories (Table 4.1). Capital costs were allocated based on similar allocation rules if costs were linked to specific personnel. For allocating non-labor capital and recurrent input costs not linked to a specific activity or personnel role, we applied an average percentage based on how total personnel time was allocated across the SEEMS codes. We excluded expenditures related to research, international staff not involved in program implementation, and non-project related activities. All capital and start-up costs were annualized using a 3% discount and useful years of capital cost were assumed to be five years. Financial data were recorded in Nepali rupees, then converted to USD using current exchange rates.

We analyzed two tiers of financial costs: 1) *National-level financial costs*, defined as SII expenditures incurred above the district level including HKI, international, and national partner financial costs and shared financial costs across the 42 districts and 2) *Subnational-level*

financial costs, defined as all financial costs incurred by local NGOs operating at district, municipality, ward, and community levels. We allocated a share of the national-level costs to the subnational-level financial costs based on the percentage of SII participants in each district to estimate total financial cost per district. Financial costs were presented on an annual basis by dividing the total costs for the program period by 3.7 years.

We estimated economic costs for an average year, including average time spent on one-time, monthly, or recurrent activities for government and program-specific frontline workers, and participants engaged in SII activities. All estimates were standardized to average time (in hours) per month spent on SII activities for each cadre involved in the program. Time estimates were multiplied by local wage rates for each cadre to value average monthly time use. We used district-specific mean daily wage rates for municipal government officers, ward chairs, district nutrition focal persons, and the unskilled labor wage rate for FCHV and participating mothers' time (Figure 4.1). The value of each cadre and participant's time was combined with out-of-pocket expenses to estimate monthly economic costs by cadre and participant. These costs were scaled (multiplied by 12) to estimate annual economic costs. Cadre-level average annual economic costs were multiplied by the number of individuals active in each district and summed to obtain district-level average annual economic costs.

Several adjustments were necessary to obtain the incremental economic costs. First, since health mothers' groups (HMG) were active before *Suaahara* II started, we estimated that 10-15 minutes of typical one-hour HMG gatherings (approximately 20%) was related to SII activities. Hence, we adjusted FCHV, CHV, and 1000-day mothers' reported time spent in HMG activities by 20%.

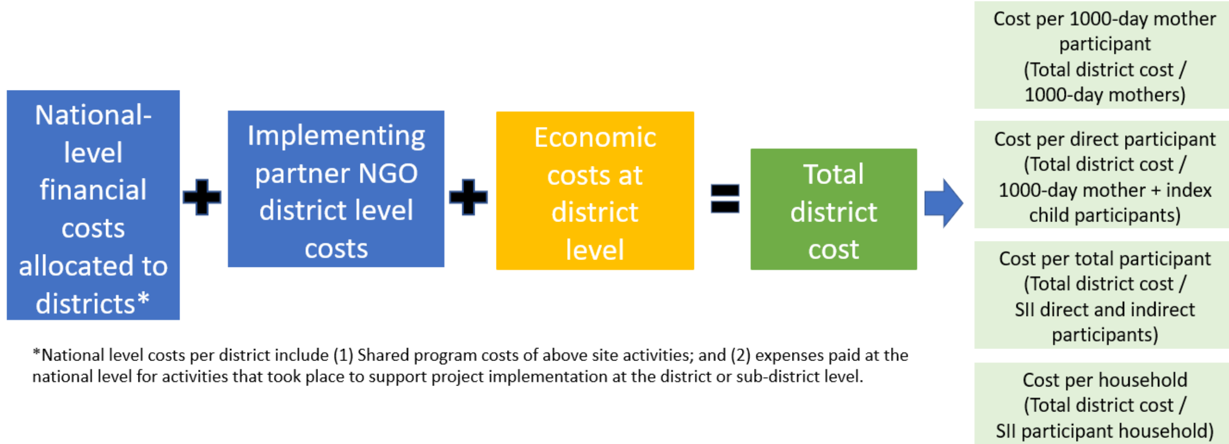
Secondly, we adjusted FCHV economic costs to reflect the reality that as uncompensated community facilitators, not all FCHVs were active volunteers. A monitoring survey conducted in

2017 by SII reported that 64.6% of FCHVs in the SII implementation area were active, so we only included economic costs for 64.6% of the total number of FCHVs in each district.[30] Third, CNVs received monthly stipends of approximately US$133, which covered transportation, communication, and time spent in SII activities. We did not include economic costs for CNVs, as their stipend was captured in financial expenditures. We also did not include time use costs for SII-compensated personnel since their salaries were captured as financial costs.

We estimated the annual total incremental cost for each district by summing annual financial and economic costs. We then estimated the weighted average total incremental cost using the percentage of the population living in each agro-ecological zone as follows: plains (46.7%), hills (43.1%), mountains (10.2%), based on National Population and Housing Census 2021 data.[143] Annual incremental cost estimates are presented for the overall sample and by district, agro-ecological zone, and length of program involvement (Figure 4.1).

The cost per 1000-day mother, per mother-child dyad, per total participant, and per household reached was equal to the total incremental cost divided by the relevant program outputs (1000-day mother, mother-child dyad, total participant, household) for each district (Figure 4.1).

Figure 4.1: Aggregation of total costs and definition of unit costs, Suaahara II



<u>Understanding government worker, frontline volunteer, and participant time</u>

We analyzed time use data for government, frontline workers and participants to better understand drivers of economic costs. We used time allocation data on the frequency and duration of home visits, travel and other time spent to estimate average monthly time use in SII activities per district. We then calculated weighted average monthly time use estimates across the four sampled districts by actor type and SII activity. We compared government worker, frontline volunteers, and participant time spent in activities by agro-ecological zone, because Nepal's diverse terrain presents different challenges in different areas, with effects on time use for program implementation.

4.3.7 Sensitivity analysis

Given the heterogeneity within and across districts in Nepal, and the relatively small sample for estimating opportunity costs, we conducted a multivariate sensitivity analysis on volunteer and participant time and out-of-pocket costs to assess uncertainty in final cost estimates. We used a Monte Carlo probabilistic analysis to generate ranges for total and unit cost outcomes while

varying underlying assumptions. We ran 5000 Monte Carlo simulations using Oracle Crystal Ball software version 11.1 (https://www.oracle.com/applications/crystalball) to draw from distributions specified for each parameter. We varied the following parameters using a gamma distribution, commonly used with costing data to non-zero estimates[144]: i) FCHV time in community events and household visits, ii) FCHV roundtrip travel time to community events and household visits, iii) FCHV out-of-pocket costs, iv) 1000-day mothers' time in community events, v) 1000-day mother roundtrip travel time to community events, vi) 1000-day mothers' out-of-pocket costs. We described ranges for each parameter below (Appendix Table 4). For each actor type we applied a gamma distribution parameterized with scale and shape estimates derived from the means and standard deviations from qualitative data.

1) Activity and travel time for FCHVs: We varied FCHV participation and travel time for community events and household visits since there was high variability in estimates across the sample.
2) Activity and travel time for 1000-day mothers: We varied mothers' participation time for community event activities since there was uncertainty in estimates due to a small sample size and community events were the overall largest share of economic costs.
3) Out-of-pocket costs for 1000-day mothers and FCHVs. We varied out-of-pocket costs because childcare, food, transportation, supplies, and communication costs varied depending on agroecological zone.

We also conducted one-way sensitivity analyses on time use for government workers to understand how increasing government involvement could affect total and unit costs. We increased time use for all five government cadres involved in SII (National Food Security Coordination Committee (NFSCC) member, Municipal Chair, Municipal Health Coordinator,

Ward Chair, District Nutrition Focal Person) by 25% and by 200% to understand the impacts of varying government employee time on SII costs.

4.4 Results

A total of 166 interviews and 8 FGDs were conducted with 230 respondents (Appendix Table 3). The average total incremental cost of *Suaahara* II was estimated to be US$908,948 per district per year for the period July 2016 – March 2020 (Table 4.2). Total incremental costs were highest in the plains and lowest in the hills at US$ $1,047,592 and US$ $754,207, respectively. On average, total financial cost per district was US$480,072. Economic costs contributed an additional US$428,876, comprising 47% of total costs (Table 4.3). Economic costs were highest in the mountains, both in absolute terms (US$499,593) and in relative terms, having the highest cost share (54%) compared to other regions.

Table 4.2: Average annual incremental costs for the Suaahara II project per district

	Financial cost	Economic cost	Total cost	%
Input				
Personnel	$266,109	$303,012	$569,121	63%
Agriculture supplies	$6,289	$0	$6,289	1%
Equipment	$6,091	$0	$6,091	1%
Contracted services	$34,843	$0	$34,843	4%
Transportation	$5,172	$0	$5,172	1%
Travel/per diem	$32,898	$38,047	$70,946	8%
Other supplies	$32,065	$70,881	$102,946	11%
Overhead	$69,466	$0	$69,466	8%
Mixed inputs	$27,139	$16,935	$44,074	5%
Total	$480,072	$428,876	$908,948	100%
Stage				
Start-up	$30,244	$16,697	$46,941	5%

Recurrent	$449,827	$412,179	$862,006	95%
Total	$480,072	$428,876	$908,948	100%
Activity				
Planning	$21,786	$2,610	$24,396	3%
Program Installation	$1,486	$2,610	$4,097	0.5%
Program sensitization	$3,765	$0	$3,765	0.4%
Recruitment	$1,470	$0	$1,470	0.2%
Training	$57,576	$11,476	$69,052	8%
Materials development	$18,692	$0	$18,692	2%
Management	$33,852	$909	$34,761	4%
Monitoring	$37,590	$583	$38,173	4%
Procurement	$2,835	$0	$2,835	0.3%
Distribution of inputs	$8,020	$0	$8,020	1%
Site supervision	$28,019	$1,589	$29,608	3%
Home visits: multi-sectoral interpersonal communication	$21,420	$134,667	$156,086	17%
Home visits for enhanced homestead food production	$7,284	$8,096	$15,381	2%
Health facility counseling and support	$3,742	$0	$3,742	0.4%
Community events and mass media	$45,137	$219,037	$264,174	29%
Health mothers' groups, adolescent groups, village model farm groups	$13,216	$46,950	$60,166	7%
Microcredit activities	$1,526	$0	$1,526	0.2%
Marketing support	$1,502	$0	$1,502	0.2%
Integration and coordination	$24,521	$349	$24,870	3%
Overhead/Indirect costs	$146,633	$0	$146,633	16%
Total	$480,072	$428,876	$908,948	100%
Sector				
Nutrition	$100,740	$171,557	$272,297	30%
Health	$92,110	$170,297	$262,407	29%
WASH	$81,506	$145	$81,651	9%
Agriculture, poultry, livestock	$26,476	$32,867	$59,343	7%
Market sector	$17,898	$0	$17,898	2%
Inter-sector	$161,342	$54,009	$215,351	24%
Total:	$480,072	$428,876	$908,948	100%

Table 4.3: Weighted total costs for the Suaahara II program per district per year, USD 2020

	Financial cost per district (US$)	Economic costs per district (US$)	Total cost per district (US$)	Financial cost (%)	Economic cost (%)
Overall	$480,072	$428,876	$908,948	52.8%	47.2%
By agroecological zone					
Mountain	$428,221	$499,593	$927,814	46.2%	53.8%
Hill	$378,767	$375,440	$754,207	50.2%	49.8%
Terai	$584,845	$462,748	$1,047,592	55.8%	44.2%
By length of SII involvement					
New district	$395,899	$335,483	$731,383	54.1%	45.9%
Continuing districts	$472,688	$446,096	$918,784	51.4%	48.6%

When considering the number of participants and households reached each year, the average unit costs were US$132 per 1000-day participating mother, US$76 per mother-child dyad, US$10 per total participant, and US$140 per household reached. The highest unit costs were in the mountain districts ($152), and lowest unit costs in the plains (US$118) per 1000-day mother (Table 4.4). The average annual cost per household was also highest in the mountains (US$159) and lowest in the plains (US$125) (Table 4.4).

Table 4.4 Incremental annual unit costs for the Suaahara II project, USD 2020

A. **Number of annual beneficiaries per district**

	Target participations		Total direct (mother + index child)	Total participants (direct and indirect*)	Households
	1000 day mothers	Index child (child < 2)			
Overall	7,063	5,049	12,112	99,419	6,639
Agro-ecological zone					
Terai	8,874	6,131	15,005	132,472	8,359
Hill	5,326	3,919	9,245	67,623	4,963
Mountain	6,111	4,870	10,981	82,380	5,848
Length of program participation					
Continuing district	7,078	5,097	12,175	95,218	6,599
New district	5,292	3,807	9,099	77,371	5,056

B. **Annual unit costs by district and participant type**

	1000-day mother	Child 0-23.9 months	1000-day mother + child 0-23.9 months	Total participants (direct and indirect*)	Households
Overall*	$131.64	$182.17	$76.38	$9.77	$140.26
Agro-ecological zone					
Terai	$118.05	$170.88	$69.82	$7.91	$125.33
Hill	$141.59	$192.45	$81.56	$11.44	$152.10
Mountain	$151.83	$190.53	$84.50	$11.26	$158.65
Length of program participation					
Continuing districts	$133.10	$182.31	$76.89	$10.63	$143.47
New district	$138.20	$192.13	$80.38	$9.45	$144.66

*Household members reached through any SII activity including mass media

4.4.1 Cost drivers

Recurrent activities drove most of the costs, with only 5% of costs allocated to start-up activities (Table 4.2). The main cost drivers by input were personnel (including volunteer) costs (63%), followed by supplies (11%), travel (8%), overhead (8%), mixed inputs (5%), and contracted services (4%) (Figure 4.2).

Mixed inputs encompassed meeting and training costs in which costs could not be disaggregated across input categories. Less than 5% of costs comprised of expenses related to agriculture supplies, equipment, and transportation. For costs by activity, community events accounted for 29% of total annual costs, followed by home visits for counseling (17%), overhead (16%), and training (8%) (Figure 4.3).

According to the nutrition-sensitive value chain typology, the majority of SII program activities focused on increasing demand for nutritious foods (67%), 17% of costs were incurred to strengthen the enabling environment for healthy nutrition, and 16% to increasing the supply of nutritious foods (Figure 4.4). Mapping costs by sector, nutrition and health sector-related activities accounted for approximately 60% of costs followed by inter-sector costs (24%). Inter-sector costs included coordination, disaster-risk reduction activities, governance, and gender, equity and social inclusion (GESI) costs. Notably, agriculture and market sector activities comprised less than 10% of costs (Table 4.2).

4.4.2 Economic costs

Time requirements from frontline workers, government, and direct program participants were captured to estimate economic costs. FCHVs had the highest monthly time use among all implementing cadres and program participants (Appendix Figure 3). FCHVs spent 27 hours per month on SII, ranging from 31 hours in the mountains to 27 hours in the plains (Appendix Figure 3). This was equivalent to spending an average of 90% (range: 68%-135%) of their work time on SII-related activities based on a 5–10 hour work week.[145] FCHVs spent 48% of their SII time organizing community events, 40% on household visits and 12% facilitating HMG meetings. Travel time consisted of 22% of overall FCHV time on SII implementation, ranging from 16% in

the plains to 28% in the hills. Village Model Farmers (VMFs) had the second highest time use. VMFs spent an average of 17 hours per month in agriculture and enhanced homestead food production support to households (12 hours on activities, and 5 hours on travel) (Appendix Figure 3). Home visits took the majority share of SII time for VMFs, with an average of 9 hours spent visiting households, with a range of 2-12 hours a month depending on agroecological zone.

Among government workers, municipal chairpersons spent 8 hours per month on SII activities followed by District Nutrition Focal Persons who spent 7 hours per month supporting SII activities (Appendix Figure 3). This was equivalent to 17-20% of a typical week based on a 40-hour work week. Government workers based in hill and mountain areas spent more time in SII per month compared to those based in the plains. Across all agroecological zones, government workers spent most of their time supporting implementation of SII at the community level.

In terms of target participants, 1000-day mothers spent 5 hours on SII activities per month with the majority of their time on community events and in HMG and VMF meetings (Appendix Figure 3). This time use estimate translated to about 4% of a typical work week, based on an assumed 6-hour day. Travel comprised 12% of total participating mothers' time spent on SII activities.

Total economic costs by actor type

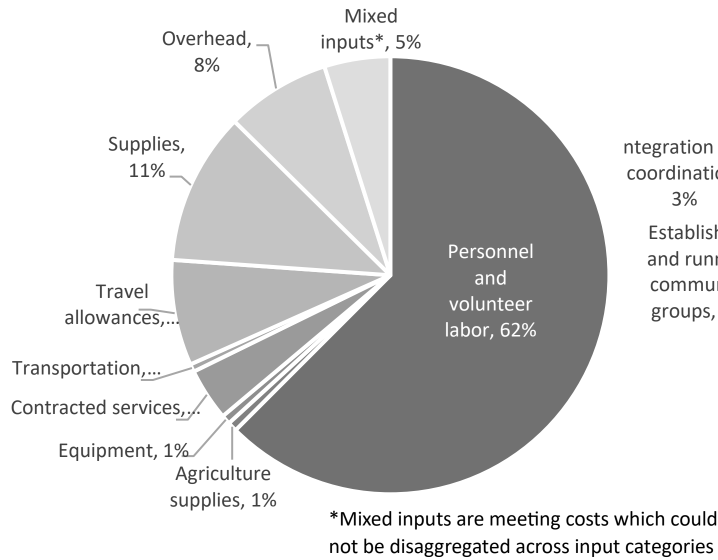
Total economic costs were highest in mountain districts and lowest in hill districts (Table 4.4). 1000-day mothers had the highest share of total economic costs (37%) followed by FCHVs (30%), Village Model Farmers (8%) and NFSCC members who support nutrition governance and coordination (7%) (Appendix Figure 4).

Although average wage rates for volunteers and women participants were lower than paid program staff or government stakeholders, FCHV and 1000-day mothers contributed the highest shares to economic costs (Figure 4.5). VMFs contributed the third highest share of economic costs with the second highest time use among all cadres. NFSCC members bore the fourth highest share of economic costs with an average of 137 members participating in SII activities per district, coupled with the second highest shadow wage.

4.4.3 Sensitivity analyses

We conducted multivariate sensitivity analyses varying activity time, travel time, and out-of-pocket costs for FCHV and 1000-day mothers as program actors with the highest share of economic costs. When we varied these parameters, total incremental costs ranged from a lower bound of US$1,149,466 to a higher bound of US$4,476,848 and the unit cost per 1000-day mother ranged from US$171 to US$698. The tornado plot (Figure 4.6) depicts variables with their corresponding magnitude of influence on total incremental cost and cost per participant. Uncertainty in time spent in community events by 1000-day mothers (range of 1.9 to 4.6 hours per month) had the largest impact on the range of costs, followed by FCHV activity time in community events and household visits.

Figure 4.2: Cost drivers by input



*Mixed inputs are meeting costs which could not be disaggregated across input categories

Figure 4.3: Cost drivers by activity

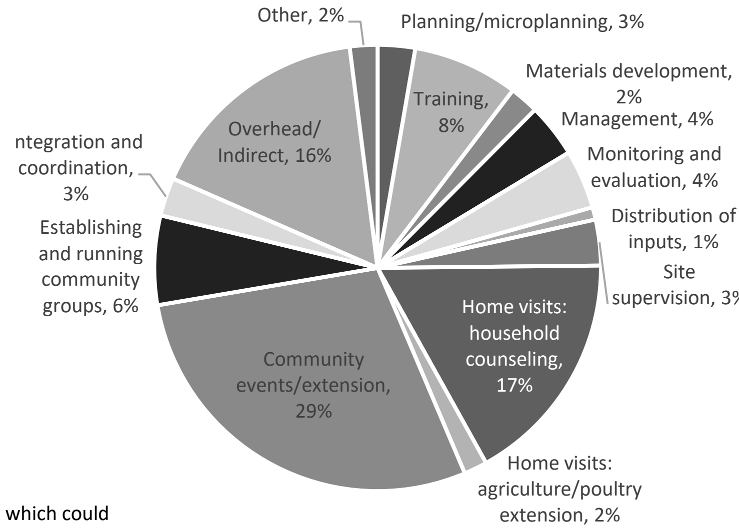


Figure 4.4: Cost drivers by nutrition-sensitive value chain

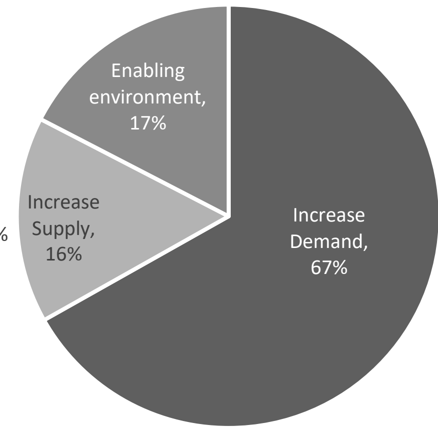
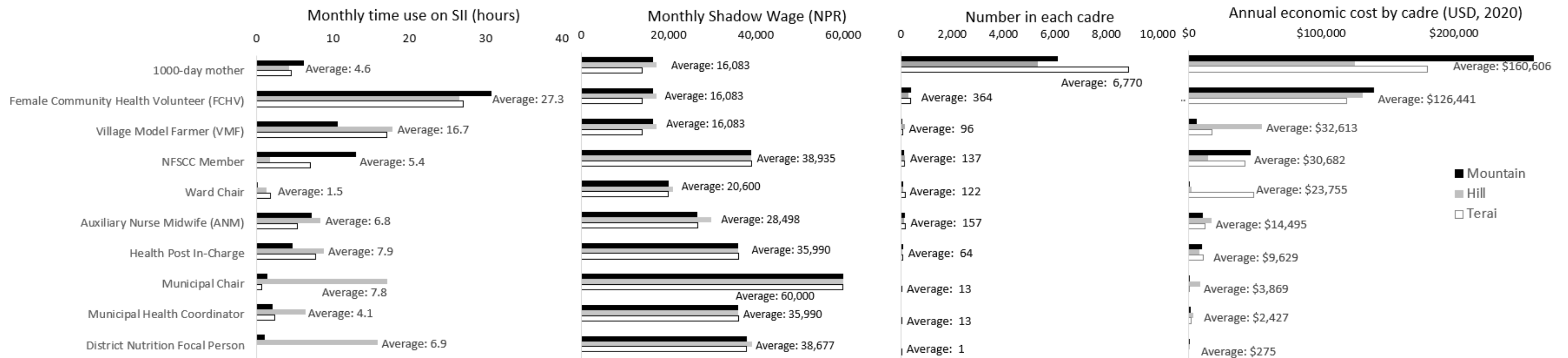
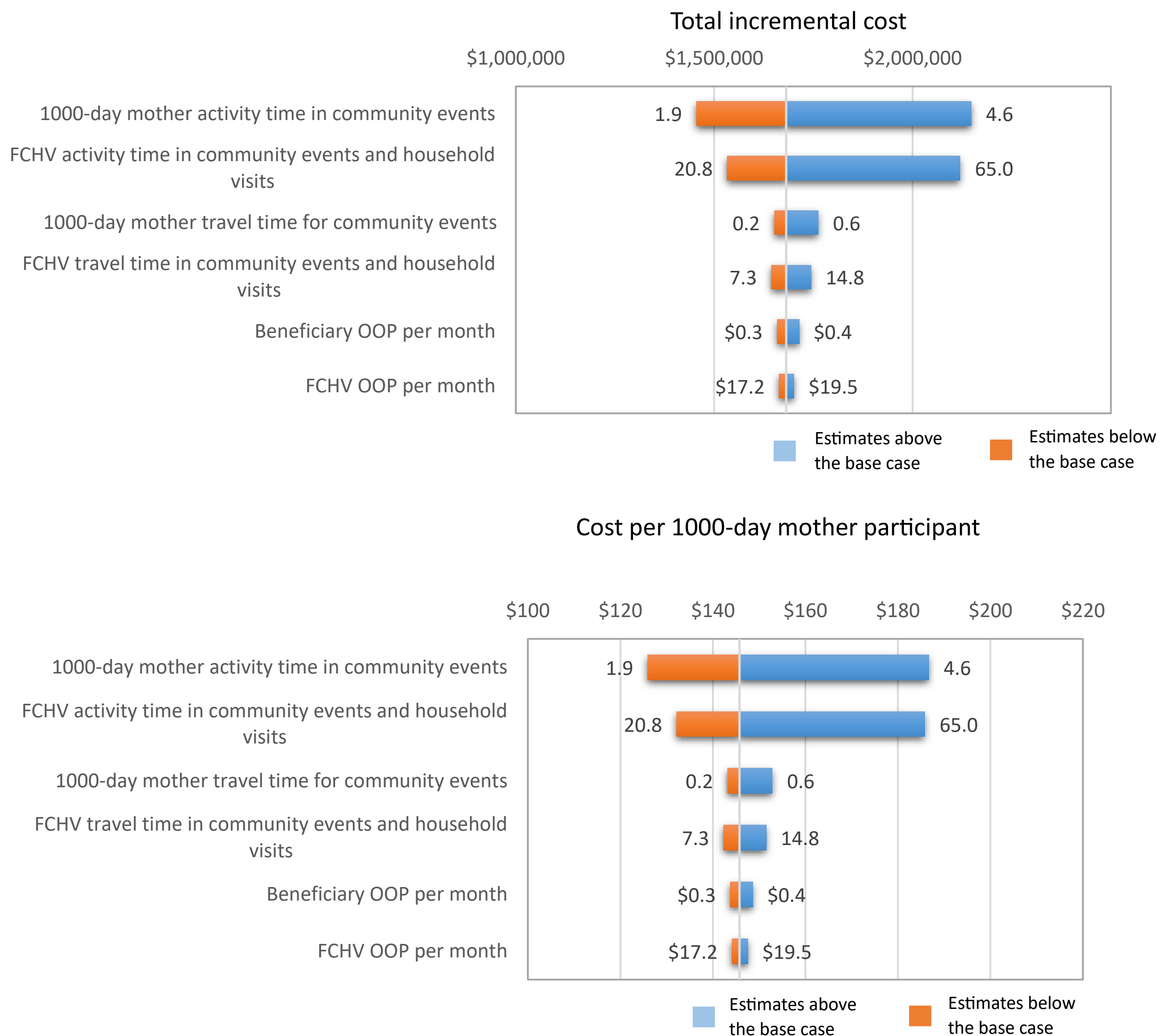


Figure 4.5: Monthly time use, shadow wages, number in each cadre and annual economic costs by ecological zone, Suaahara II



To explore varying government worker involvement in SII, one way sensitivity analysis showed that the cost per 1000-day mother increased to $135.36, a 1.8% increase from the base case and total cost increased by 2% ($925,968) if NFSCC member time spent on SII was doubled in each sampled district (Appendix Table 5). Increasing other government workers' time by double changed total and unit costs by less than 1%.

Figure 4.6: Tornado diagrams for sensitivity analysis of total and unit incremental costs (cost per 1000-day mother, *Suaahara* II)



4.5 DISCUSSION

This study captured the total incremental costs of a donor-supported multi-sectoral nutrition program that reached over 2 million direct participants in support of Nepal's MSNP. The USAID funded SII program, implemented by both international and local NGOs, invested in strengthening awareness and practice in the production and consumption of nutritious foods, enhancing the effectiveness of local governance, and promoted quality health services to improve maternal and child nutrition outcomes. SII was an ambitious program implemented in 42 districts (389 municipalities) reaching over 2 million direct 1000-day mothers and children under two years, and an additional 9 million household members using a family centered approach that relied on community SBCC interventions to create a supportive and enabling environment to improve maternal and child health outcomes. Consistently reaching 1000-day mothers and their families required an intervention that was complex in scope, spanning multiple sectors with multiple points of contact, implemented at multiple administrative levels (national and subnational) and reliant on management and technical support from HKI, six international partners and over 40 local district community-based organizations.

We applied the SEEMS-Nutrition standardized costing approach to facilitate comparisons with other multisectoral nutrition programs and to capture the full range of resources required for implementation. The average annual cost of reaching 1000-day mothers was $132 per woman and reduced to $76 when considering their children under 2 years of age. These unit costs of SII are similar to other multi-sectoral nutrition interventions in Malawi and Bangladesh that used the SEEMS approach, with costs ranging from US$112-$160 per participant.[139,140] Although these programs vary in target population and program components, they all share a strong focus in SBCC activities to change knowledge, attitude and practices for producing and consuming

nutritious foods. When considering the larger reach of SII to the broader community, beyond mother-child dyads, the unit cost of SII as a community wide program declines significantly. The cost of reaching both total household members (approximately 11 million, or typically around 80% of the total district population) was $10, with the lowest unit costs in districts based in the plains at $8 per individual. While SII's intervention components and unit costs per participant were comparable to other multisectoral nutrition interventions,[139,140,146,147] its scale was much larger than similar cost studies published to date, illustrating the advantage of economies of scale when integrating programs into existing health and governance infrastructure.

Considering costs by agroecological zone or other meaningful program characteristics provides insights for programs implemented nationally or outside of Nepal. In a scaled-up program that spanned several investment phases, bringing new districts from one phase to the next may have some benefits in keeping costs low. Although the average unit costs for new districts that joined later in SII were higher than established districts from SI, the difference was marginal. New districts introduced in SII benefited from a well-honed program, training workshops, materials, monitoring systems and existing community-based processes, such as the FCHV network. The increase in overall costs reflected higher opportunity costs (resource use) by new participants. When exploring resource allocation across nutrition sensitive intervention typology, SII allocated over 65% of all resources to improve the demand for nutritious foods, slightly higher than programs in Malawi (53%) and Bangladesh (50%).[13,14.]

Capturing the economic or opportunity costs of volunteer frontline workers and participants is critical for estimating total resources required to implement multi-sectoral interventions supported by local governance and communities themselves. Our analysis showed that economic costs comprise on average 47% of total costs and up to 56% in mountainous zones,

slightly higher than other cost studies.[138,139] Total financial costs were highest in the plains, with higher population density and greater program reach, and lowest in the remote mountain region, with lower density and fewer participants reached. Yet, when including the opportunity costs of time, including travel, total economic costs were highest in the mountains. Unit costs were also highest in the mountains, reflecting greater travel time in mountain areas due to household dispersion and access constraints such as distance and poor roads. In the lowland plains region, the share of economic cost was lowest, as were costs per participant. Estimating both financial and economic costs can inform program design, budgeting, and resource allocation based on need, as not all districts are alike, considering some districts may need extra resources to facilitate greater participation. Additionally, including opportunity costs may help to identify efficient or lower cost delivery strategies that reduce time burden, reduce costs, and improve reach.

Complex multi-sectoral programs often require significant resources to ensure coordination and sufficient technical support is provided to implementers at the district-level or below. SII not only coordinated across sectors, but also across implementation levels from national to sub-national to identify and strengthen collaborations. Using a multi-sectoral and multi-level approach facilitates synergies across stakeholders but requires ample investment in personnel costs, integration, and coordination costs. High personnel costs are common in these programs as large numbers of staff are involved in implementation across sectors.[137–139] As noted, SII's inclusion of a wide range of activities across sectors required engagement of diverse organizations with experience and expertise spanning multiple sectors and levels. Technical assistance, management, coordination, and oversight of this large-scale program accounted for 53% of total costs.

Since working closely with communities has implications for time use and management, we explored how SII affected frontline volunteers, government workers, and participants' time. First, SII activities were designed to be integrated into existing rural and urban community health extension networks. The program leveraged an existing FCHV network, a key component of Nepal's health system, equipping them with greater tools to reach households including directed trainings.[77] Therefore, understanding the time invested by FCHVs in SII was important to consider for Nepal's expansion of their national MSNP. FCHVs spent 28 hours per month on SII activities, falling within the range from other studies on community health volunteer time use. Unpaid Community Health Workers (CHWs) in Uganda had a monthly workload of 19.3h, while part-time paid CHWs in rural India spent 25.3h per week on health and nutrition activities.[148,149] In Nepal, FCHVs typically volunteer 5-10 hours per week, suggesting that SII activities likely complemented existing FCHV duties including immunization and vitamin A supplementation.[77,145,150] Using this range of work hours, some FCHVs involved in SII may have increased their work hours to accommodate for a higher workload (7 more hours per month, a 35% increase). Thoughtful partnerships between implementers and FCHVs are vital to avoid overburdening community volunteers. Second, we explored the impact of SII on government worker time. Since government time spent on SII was relatively low, we used sensitivity analysis to double their total SII-related time commitment, revealing that this change in time use did not affect overall costs substantially. Although there was a limited number of government workers involved in direct implementation of SII, especially at the municipality level and above, transitioning to government led MSNP implementation in these 42 districts would require more extensive involvement of government workers to coordinate, manage, and ensure collaboration across sectors and implementation levels. Strengthening coordination bodies such as local

NFSCCs may be a key approach to accelerate nutrition governance and action. Third, we explored 1000-day mothers time in SII activities. On average, 1000-day mother participants spent 4.6 hours per month, or less than 3% of a typical working month, in program activities. This estimate is lower than other time use studies of nutrition-sensitive programs involving women.[151] Understanding costs associated with measured changes in IYCF, such as improved dietary practices, suggests that engaging mothers frequently through regular interaction, not necessarily requiring extensive time, may be an effective approach to provide support in the first 1000 days.

Further analysis comparing SII costs to the government's cost of implementing the MNSP could help to assess affordability of an enhanced government owned and implemented program like SII. Similarly, a future analysis comparing the costs to measured impact outcomes will provide additional evidence on return on investment for SII and can inform donor and government planning and decision making.

4.5.1 Limitations

This study had several limitations. Cost data were collected from four of 42 SII implementation districts due to budget and logistical constraints. To address representativeness, we sampled districts across agro-ecological zones, and included both new and previously supported districts to maximize variation. We did not scale cost estimates to the full 42 districts as we did not want to introduce bias due to our sampling strategy. Qualitative data were collected in different seasons to capture average time use across seasons, but limited interpretations can be made for opportunity costs within a single season. Increases in women's opportunity cost of time as a result of participation in nutrition-sensitive programs during peak agriculture season has been

shown to negatively impacted women's dietary intake, but this study did not capture resource use linked to seasonal agricultural activities.[152] In addition, the mode of data collection for interviews changed due to COVID-related restrictions on travel from in person to over the phone. To ensure data comparability, we asked about typical time spent on activities prior to COVID restrictions during phone interviews.

4.6 Conclusion

This study provides evidence on the costs of SII, a scaled-up multi-sectoral nutrition program, including insights into opportunity costs for health volunteers and program participants. Costs of these programs can be substantial, and vary by agroecological zone and reach, especially when considering opportunity costs. Estimating both financial and economic costs can better inform program design, budgeting, and resource allocation for scaled up programs, taking into consideration variations in population density, geographic location, and program participation. Initiatives such as SEEMS-Nutrition are contributing to expanding the evidence base around the costs of multi-sectoral nutrition strategies with standardized guidance to conduct these studies.

Chapter 5. Conclusion

This dissertation demonstrates the critical role of food environments and behavioral factors on consumption of healthy and unhealthy foods and the costs of implementing a program that intervened to improve food environments and diets in Nepal.

We highlighted the gap in food environment research in LMICs to better understand how diets are shaped by both external and individual-level factors. We demonstrate the FERA can be inserted into an ongoing household or monitoring survey to collect data on food environments in LMICs. We also illustrate the utility of classifying households by food environment type based on food environment scores for healthy and unhealthy foods. This typology can be used in future analysis to compare characteristics of living in food oasis, food deserts, food swamps and food abundant areas. We used the FERA and food environment types to demonstrate that food environments were strongly associated with diets, living in food oases was protective of unhealthy diets, and living in food deserts and food swamps were linked to unhealthy consumption. This suggests the important role of food environments in shaping dietary behaviors and calls for urgent action to curb the rise of unhealthy consumption in Nepal.

Furthermore, we highlight the application of a behavioral implementation science framework to study child diets in a low-middle income setting using secondary data. We demonstrate that implementation science frameworks can be used retrospectively to identify determinants of infant and young child feeding behaviors. Employing the TDF in this manner can help to identify potential implementation and behavioral factors more comprehensively and facilitates comparisons across studies. In addition, novel applications of implementation science frameworks to study infant and young child dietary practices are feasible and help to build the

field of implementation science in nutrition and food security. Our findings also support the WHO and UNICEF's recommendations to practice responsive feeding as a critical component of IYCF practice. Active participation in community health groups also has positive implications on child diets. Community health groups are important spaces for caregivers to convene with FCHVs, converse, and share peer learning. FCHVs play a vital role in facilitating and leading these groups.

Moreover, we present the costs of a scaled-up multi-sectoral nutrition program, the *Suaahara* II program, that intervened to improve food environments and behavioral determinants of IYCF practice. Studying the costs of a program helps to understand a program's affordability and potential for scale up. This costing study estimated the full cost of SII, including both financial and economic costs of program implementation. Of note, we showed that economic costs of a large scale multi-sectoral nutrition program are substantial, with community health volunteers and program participants bearing the largest burden of economic costs in the form of time use and out of pocket costs. Though FCHVs are an integral component of the Nepali health system, thoughtful and equitable partnerships are needed to ensure volunteers are not overburdened. In addition, greater involvement of government workers at every level of implementation of a scaled-up multi-sectoral nutrition program is critical to strengthen the transition to eventual government-led MSNP implementation in the SII areas.

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Appendix

Figure 1: Suaahara II Theory of Change

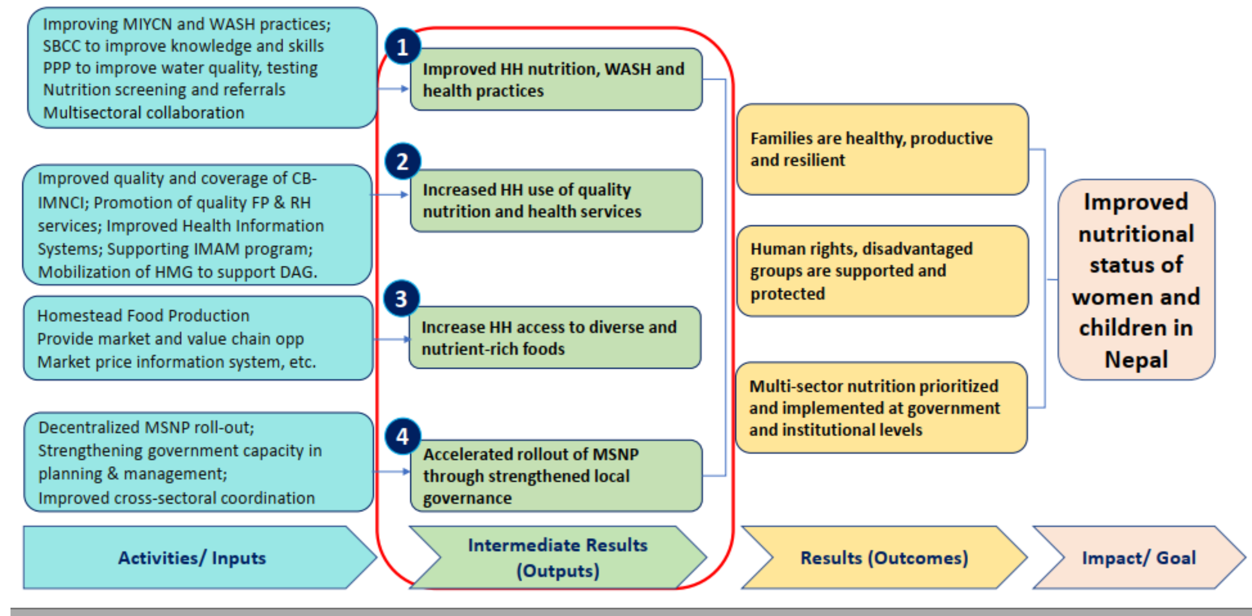
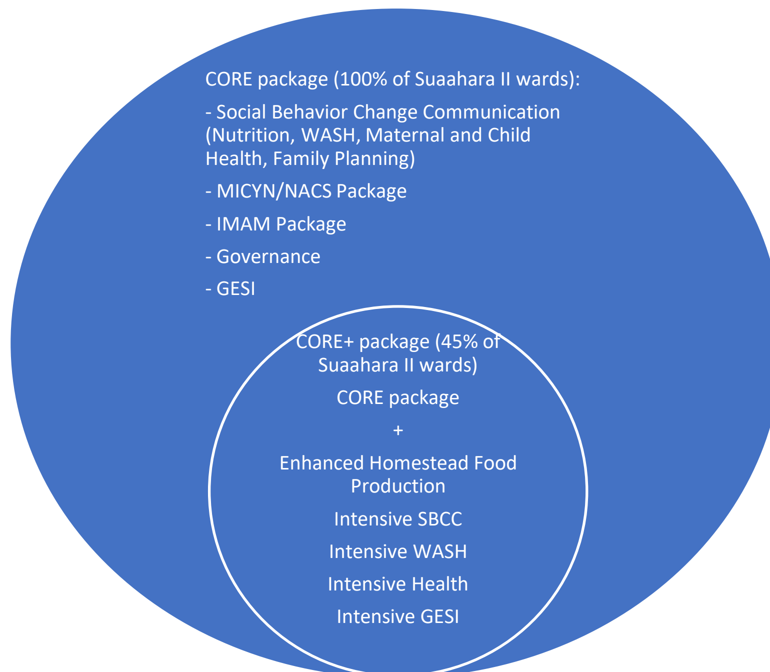


Figure 2: Suaahara II CORE and CORE+ components



CORE package applies to all the Suaahara II intervention wards, while CORE+ applies to 45% of the intervention wards.

Table 1. Cadres and participants involved in the Suaahara II (SII) program activities.

Category	SII role	Description of involvement in SII
Program participants	1000-day mothers	The SII program focused on the 1000-day period with pregnant women and mothers of children < 2 as target program participants. 1000-day mothers participated in behavior change activities at their homes and during community events. Activities included learning about improved practices for nutrition, health, WASH, and homestead food production aimed at improving the well-being of both the mother and baby.
	Household members	Indirect program participants include grandparents, husband/partners of 1000-day mothers, and other children in the household.
Frontline worker	FCHV	FCHVs facilitated health mothers' groups, conducted home visits, and reporting. SII supported FCHVs to organize community events, such as food demonstrations and Enhanced Homestead Food Production (EHFP) demonstrations.
	CNV	Community Nutrition Volunteers (CNVs) identified mothers in the 1000-day period, supported frontline workers, such as FCHVs and healthcare professionals at Primary Health Centers (PHC), as well as at outreach and immunization clinics. CNVs also support Village Model Farmers (VMFs) and Household Food Production (HFP) groups.
	Field supervisor	Field supervisors (FS) were SII field staff responsible for implementing program activities. FS coordinated with government officials and other stakeholders at the community level. They planned and executed Suaahara II activities, overseeing the work of Community Nutrition Volunteers (CNVs), monitoring the progress, providing support FCHVs, outreach clinics, and Community-Based Organizations (CBOs), ensuring timely reporting of activity progress.
	Health post in charge	The SII program staff trained healthcare workers at local health facilities to deliver better maternal and child health, as well as nutrition services. Throughout the program, healthcare workers (Health post in-charge, ANM) actively participate in different on-site coaching sessions.
	Auxiliary Nurse Midwife (ANM)	
	VMF	Village Model Farmers are progressive women leaders, 1000-day mothers, and Female Community Health Volunteers. VMFs receive diverse training focused on group management, social mobilization, larger-scale vegetable and poultry farming, agricultural marketing, and climate-smart agricultural technology demonstration. VMFs play a crucial role as catalysts for improving the production of nutritious food within their communities. They receive ongoing technical support and contribute by providing vegetable seeds or chicks from their own production. Additionally, VMFs collaborate with local municipal agriculture and livestock units to leverage government resources.
Government workers	Municipal health coordinator	SII supported the Government of Nepal (GoN) at three levels of government in designing, implementing, and rolling out the GoN Multisector Nutrition Plan (MSNP). SII fostered local ownership of the program by engaging various government officials in planning, coordination, implementation, monitoring, technical visits, and program activity reviews. Government officials received training in nutrition governance and budgeting initiatives. Government workers also actively participate in SII community events, including fairs, exhibitions, promotion campaigns, and various celebrations.
	Municipal chair	
	Ward chairperson	
	District Nutrition Focal point	
	NFSCC members	

Table 2. SII inputs mapped to SEEMS-Nutrition input categories

SEEMS Input category	SII Inputs
Personnel	Suaahara II staff paid time, paid and volunteer frontline workers, participant time
Equipment	Capital goods including laptops and vehicles
Contracted services	Consultants for technical assistance, training costs for rentals, venue
Transportation	Fuel, maintenance
Travel/per diem	Travel allowances, per diems
Other supplies	Office supplies, refreshments
Overhead	Facilities and office rent, communication costs

Table 3: Qualitative sample by district for Suaahara II cost study

Category	Cadre	Dhading		Sindhupalchok		Nawalparasi		Bajhang		Total
		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	
Direct participant	1000-day mother participant	6	16	5	5	6	7	10	9	64
Frontline	Female Community Health Volunteer	9	9	2	2	2	2	2	2	30
	Community Nutrition Volunteer	6		2	2	2	1	2	2	17
	Field Supervisor	6		2	1	1	1	2	2	15
	Health post in charge	1	2	2	0	2	2	1	1	11
	Auxiliary Nurse Midwife	1	1	0	1	2	2	2	2	11
	Village Model Farmer	n/a	1	2	1	1	1	1	1	8
Government	Health coordinator	1	2	2	1	2	2	1	1	12
	Municipal chairperson	1	2	1	0	1	1	0	0	6
	Ward chairperson	0	2	2	1	1	1	1	1	9
	District nutrition focal person	1		1						2
	NFSCC member	0	2	2	1	3	3	1	1	13
Staff	Local NGO finance officer	1		1		1		1		4
	Local NGO field coordinator	1		1		1		1		4
	Local NGO Executive Director			1		1		1		3
	SII finance officer	1		1		1		1		4
	SII HFP officer	1				1		1		3
	SII MNCH/GESI officer	1		1		1		0		3
	SII NSBCC officer	1		1		1		1		4
	SII program coordinator	1		1		1		1		4
	SII WASH officer	1		0		1		1		3
Total respondents										230

* SII: Suaahara II program; HFP: Homestead Food Production; MNCH: Maternal, Newborn, and Child Health; GESI: Gender and social inclusion; NSBCC: Nutrition social behavior change communication; WASH: water, sanitation, and hygiene

Figure 3: Monthly time use on Suaahara II by cadre (hours)

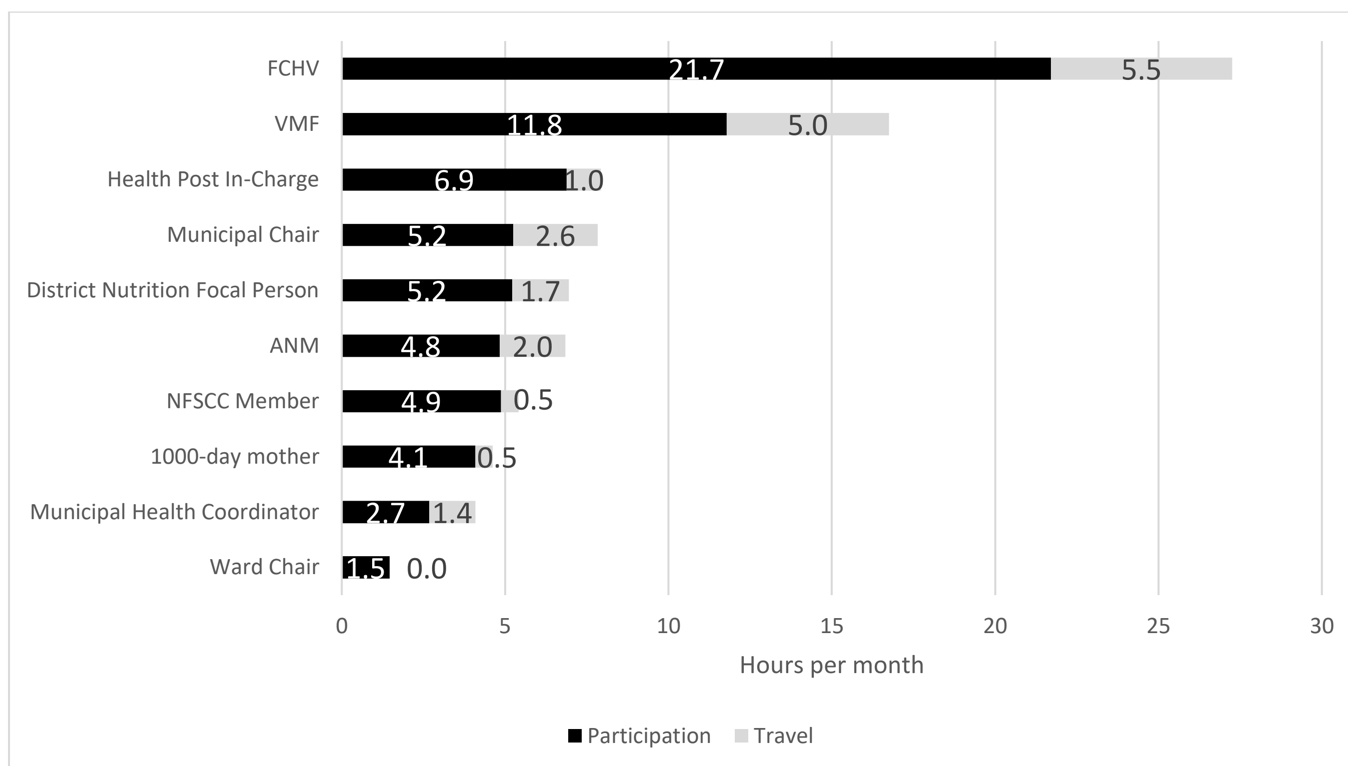


Figure 4: Economic cost by cadre and participant

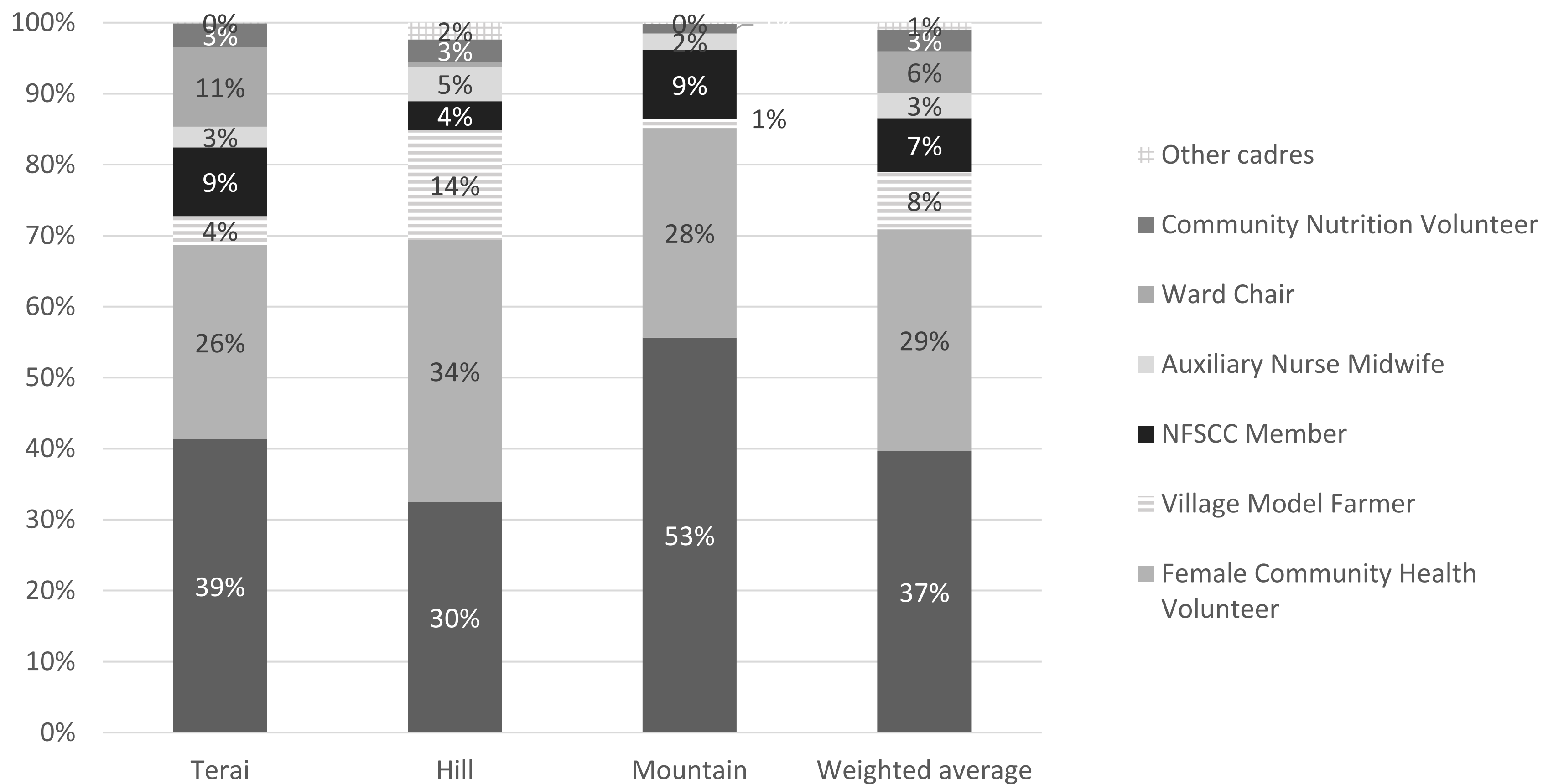


Table 4: Multivariate sensitivity analysis parameters and results for Suaahara II cost study

Parameters	Mean	Standard deviation	PSA Distribution
1000-day mother			
Activity time in community events per month (hours)	1.53	1.18	Gamma
Travel time for community events per month (hours)	0.17	0.17	Gamma
Out of pocket costs per month (US$)	$0.2	0.07	Gamma
Female Community Health Volunteer			
Non-HMG activity time per month (hours)	19.09	20.29	Gamma
Non-HMG travel time per month (hours)	5.27	3.06	Gamma
Out of pocket costs per month (US$)	$10.45	1.18	Gamma

*Abbreviations. HMG: Health Mothers Group, PSA: Probabilistic sensitivity analysis, FGD: Focus group discussion

Table 5: One way sensitivity analysis varying time use for government workers in Suaahara II (USD 2020)

	Total cost	Cost per 1000-day mother	Cost per direct participant (mothers + child)	Cost per direct + indirect participants	Cost per household
Base case (mean)	$908,491	$131.64	$76.38	$9.77	$140.26
NFSCC member					
Increase time use by 25%	$912,867	$133.57	$77.50	$9.90	$142.30
Double time use	$925,968	$135.36	$78.54	$10.03	$144.20
Ward chair					
Increase time use by 25%	$909,123	$133.06	$77.21	$9.87	$141.76
Double time use	$911,018	$133.32	$77.36	$9.88	$142.03
District Nutrition Focal Person					
Increase time use by 25%	$908,512	$132.98	$77.16	$9.86	$141.67
Double time use	$908,574	$132.99	$77.17	$9.86	$141.68
Municipal chair					
Increase time use by 25%	$908,995	$133.07	$77.21	$9.87	$141.76
Double time use	$910,504	$133.34	$77.37	$9.88	$142.05
Municipal Health Coordinator					
Increase time use by 25%	$908,817	$133.03	$77.19	$9.86	$141.72
Double time use	$909,793	$133.19	$77.28	$9.87	$141.89

Abbreviations. NFSCC: Nutrition and Food Security Coordination Committee