Homestead Vegetable and Poultry Production and Related Practices: An Assessment in Nepal

Shiva Bhandari

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Homestead Vegetable and Poultry Production and Related Practices: An Assessment in Nepal

by

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DEDICATION

To all the farmers, for their perseverance to feed the world.
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ABSTRACT

Consumption of nutrients-rich foods like diverse vegetables, eggs, and meat throughout a year remains a challenge in low- and middle-income countries due to poor availability, accessibility, and affordability. One important way to overcome the challenge is to promote households’ own production of these foods and encourage individuals to consume. Improving household production of the foods necessitates understanding whether active participation and performance of frontline workers in the communities and performing improved production-related practices can translate into improved production of nutrients-rich foods. This study had two specific aims. The first aim was to examine demographic, socio-economic, and programmatic determinants of active participation and performance of village model farmers (VMFs), the frontline workers in the HFP program. The second aim was to investigate whether improved gardening and poultry-raising practices promoted in the communities were associated with improved household vegetable and poultry production.

To achieve these aims, two separate cross-sectional Suaahara-II, a multi-sectoral nutrition program, datasets were used. Information was collected from among 4,750 VMFs and 3,635 households from Suaahara-II. The active participation and performance of VMFs was defined as summed score of the number of four activities that they performed: registered their HFP group with the local government, conducted regular group meetings, discussed vegetable growing and chicken rearing practices with group
members, or engaged in saving and credit activities in their HFP group. Improved gardening and poultry-raising practices scores were created by summing improved gardening and poultry-raising activities practiced by the households. Vegetable production was assessed using: (i) vegetable production diversity score (0 to 5), generated by categorizing 35 vegetables produced into 5 groups and summing them: dark-green leafy vegetables, other vitamin A-rich vegetables, beans and pulses, roots and tubers, and other vegetables, and (ii) quantity produced (kg). Poultry production was assessed by counting the number of chickens and eggs produced in the households in the last month. Potential socio-economic and demographic determinants were identified \textit{a priori} and adjusted for clustering. Ordinal regression models were used to examine the association between the potential determinants and active participation of the VMFs. Linear mixed-effects and left-censored regression models were used to examine the associations between the practices and production.

Higher levels of education, being a female community health volunteer, being from an upper caste household, and having received more additional trainings and inputs were associated with more active participation among the VMFs retained in the HFP program. Vegetable production diversity and quantity, egg, and chicken production were greater for those households performing a greater number of improved gardening and poultry raising practices, respectively. When designing large-scale nutrition-sensitive agriculture programs, providing trainings, but also inputs to the farming households to support their adoption of these improved practices will be critical for ensuring increased and more diverse household production of nutrients-rich foods.
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LIST OF ABBREVIATIONS

ADS............................................................... Agriculture Development Strategy
DGLV .............................................................. Dark Green Leafy Vegetables
FCHV ............................................................. Female Community Health Volunteer
HFP ................................................................. Homestead Food Production
HKI ................................................................. Helen Keller International
LMIC............................................................. Low- and middle-income Countries
MNSP............................................................. Multi-Sectoral Nutrition Plan
NAP ................................................................. National Action Plan
NCD ............................................................... Non-communicable Diseases
VMF ............................................................... Village Model Farmer
CHAPTER 1
INTRODUCTION

Malnutrition is a significant global health challenge. Low- and middle-income countries are grappling with the triple burden of malnutrition: increasing rates of overweight and obesity alongside persistent rates of undernutrition reflected by stunting (low height for age), wasting (low weight for height), underweight (low weight for age), anemia (hemoglobin concentration < 120 g/l (for non-pregnant women and children above 12 years of age) and < 110 g/l (for pregnant women and children 6 to 59 months of age) at sea level), and vitamin and mineral deficiencies among children under 5 years of age and women (Dietz, 2017; Prentice, 2018; Tzioumis, Kay, Bentley, & Adair, 2016; WHO, 2010, 2011).

Poor diet, defined as a low intake of nutrient-rich foods such as meat, fish, eggs, fruits, and vegetables but high intake of highly processed foods (Troesch et al., 2015), is an important cause for the afore-mentioned health problems. Nutrition transition from high-fiber traditional diets with minimal processing to modern diets that are highly processed and rich in red meat, sugar, salt, and cholesterol has also contributed to the poor diets (Popkin, Adair, & Ng, 2012). In addition, with globalization, urbanization, and trade liberalization, food systems (defined as all elements and activities that relate to production, processing, distribution, preparation, and consumption of food) are changing, playing an important role in what people eat (Walter Willett et al., 2019). Low consumption of nutrient-rich foods, important source of proteins, vitamins and minerals
required to remain healthy (Slavin & Lloyd, 2012), can be attributed to low accessibility, affordability, convenience, consumption behaviors, and lack of knowledge of the importance of such foods, availability, prices, markets, and food policies (Appleton et al., 2016; Bodor, Rose, Farley, Swalm, & Scott, 2008; Miller et al., 2016b; Turner et al., 2018b).

Availability, accessibility, and affordability of fruits and vegetables, meat, and eggs is challenging, especially where market connections and infrastructure are limited, and households lack motivation for production (Miller et al., 2016b). Lack of markets in rural settings leave people with no option for purchasing nutrient-rich foods. If markets are present, they mainly sell staple foods (such as rice, wheat, and potatoes), oils, sugar, salt, and spices/condiments that people want to buy frequently. In addition, nutrient-rich foods are expensive causing 1.9 billion people in Asia and 965 million people in Africa being unable to afford such foods (FAO, IFAD, UNICEF, WFP, & WHO, 2020). For example, in Asia, dark green leafy vegetables are 5-9 times more expensive (in terms of per unit of energy) than staple cereals (D. D. Headey & Alderman, 2019). Even the most affordable diet proposed by the EAT-Lancet commission (Walter Willett et al., 2019) cost about US$3 per day in 2011, of which the largest share was the cost of fruits and vegetables (31%) (Hirvonen, Bai, Headey, & Masters, 2020). A recent report showed that a healthy diet (defined as a diet adequate in calories and nutrients, and includes foods from several different food groups) cost 60% more than diets that only meet the requirements for essential nutrients and almost 5 times as much as diets providing adequate calories only (usually met through a starchy staple) (FAO et al., 2020). In Nepal, the cost of an optimal diet that includes nutrient-rich foods is high (Akhter et al.,
2018; Biehl et al., 2016). High costs, lower income, and lack of nutritional assistance hinder the purchase of nutrient-rich foods by poor and disadvantaged people (Hirvonen et al., 2020). In addition, during and after emergencies like the current COVID-19 pandemic has resulted in increased prices of commodities including nutrient-rich foods (Singh, Nourozi, Acharya, & Thapa, 2020).

One of the ways to deal with the issues of availability, affordability, and accessibility where markets cannot function well is to promote household production, a well-documented nutrition-sensitive agriculture intervention (Marie T Ruel & Alderman, 2013; Marie T. Ruel, Quisumbing, & Balagamwala, 2018). Household production of nutrients-rich foods can be important to reduce malnutrition (both under-nutrition and overweight/obesity) because the likelihood of consumption of nutrient-rich foods increases if households produce these foods (P. Mulmi & Masters, 2017). Promotion of homestead food production of nutrients-rich vegetables, fruits, and small livestock can improve dietary quality of foods (Dulal, Mundy, Sawal, Rana, & Cunningham, 2017; Verbowski et al., 2018), household food security (Talukder et al., 2010), hemoglobin levels (Kennedy, Kadiyala, Daniel, Poole, & Olney, 2017), and reduced stunting among children (Talukder et al., 2010). In addition, household production by smallholder farmers (usually practice subsistence farming and sometimes with a mixture of cash crops) contributes about 28-31% of total crop production and 30-34% of food supply in the world (Ricciardi, Ramankutty, Mehrabi, Jarvis, & Chookolingo, 2018). Furthermore, household production among small-holder farmers is crucial for those who cannot afford the cost of nutrients-rich foods or where markets or shops are inaccessible (Biehl et al., 2016; Hirvonen et al., 2020).
In Nepal, household food production has been promoted by *Suaahara*, a multi-sectoral integrated nutrition program, to encourage consumption of nutrient-rich foods and to improve household food security and nutritional outcomes among children and mothers. *Suaahara’s* homestead food production (HFP) program consists of collaborated efforts with local farmers and community organizations to establish Village Model Farmers (VMFs), also referred to as frontline workers, and provide them with hands-on training in nutrition-sensitive agricultural practices. VMFs, once trained, become community-level extension workers or change agents and promote garden to plate (agriculture to nutrition) activities among households in their communities. VMFs provide agricultural inputs and information to households and teach through demonstration so that the households can increase and diversify their production to ensure availability of nutrient-rich foods throughout the year. Women were primarily selected as the VMFs because in addition to own consumption and market linkages, women’s empowerment has been identified as a primary pathway for agriculture to improve nutrition (Stuart Gillespie, Harris, & Kadiyala, 2012; D. Headey, Chiu, & Kadiyala, 2012). Also, in Nepal women provide most of the labor force for agricultural production in addition to their traditional household chores (FAO, 2019; Food and Agriculture Organization, 2011). In addition to the community level VMFs, household level beneficiaries receive a 2-day basic HFP training, distribution of 3 packets of seasonal seeds during the year immediately following the basic HFP training, distribution of 5 chicks, and linkage with a VMF for further inputs.

One way to improve household production is to improve production-related practices and understanding the socio-demographic determinants of active engagement of
village model farmers in the communities. In addition, understanding vegetable and poultry production and related practices is a crucial step in achieving improved nutrition and food security outcomes. Government of Nepal has also identified the need for improved agricultural practices and animal husbandry practices to achieve higher productivity and household food security (Ministry of Agricultural Development, 2014). A dearth of evidence exists, however, on whether improvements in production-related practices translate into greater household production of nutrient-rich foods among people in communities. Moreover, little is known about what and how different demographic and socio-economic characteristics influence active engagement of VMFs in improving production of nutrients-rich foods. Production-related practices along with trainings, inputs, and awareness-creation activities are important to promote improved food production diversity and consumption choices (Bernet et al., 2018; Marie T. Ruel et al., 2018). VMFs’ active engagement and promotion of production-related practices might be a window of opportunity for nutrition-sensitive agriculture interventions to foster production of vegetables, eggs, and chicken in sustainable way.

1.1 Research goal and aims

The goal of this study is to improve our understanding about socio-economic determinants of village model farmers and production-related practices promoted by HFP program to improve vegetable and poultry production in disadvantaged communities of Nepal. The specific aims of the research are:

Specific Aim 1: To test the determinants of village model farmers’ (VMFs) engagement in the HFP program several years after being selected as VMFs.
**Research Question**: What is the association between socio-economic and demographic characteristics of VMFs and working actively in the HFP program after several years of being selected as VMFs?

**Specific Aim 2**: To estimate the association between gardening and poultry-raising practices and vegetables and poultry production among households in Nepal.

**Research Question**: What is the association between improved gardening and poultry-raising practices and vegetable and poultry (chicken and egg) production, respectively among the households in Nepal?

**1.2 Overview**

This dissertation research has been organized in five chapters. Chapter 2 includes background on poor nutrition due to low consumption of nutrients-rich foods, role of household food production, agriculture and livestock situation, and related policies in Nepal. The chapter also includes research gaps, theoretical framework guiding this research, and research significance. Chapter 3 includes research methodology. Chapter 4 presents the results in the form of two distinct manuscripts. Chapter 5 summarizes the findings and discusses on the implications of the findings and direction for future research.
CHAPTER 2
BACKGROUND AND SIGNIFICANCE

Malnutrition or poor nutrition is a serious health challenge to achieve the Sustainable Development Goals by 2030, especially Goal 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture) and Goal 3 (Ensure healthy lives and promote well-being for all at all ages), proposed by the United Nations (United Nations, 2015). Malnutrition coexists in two forms: undernutrition reflected by underweight (low weight for age), wasting (low weight for height), and stunting (low height for age); and overnutrition reflected by overweight, obesity (Body mass index (BMI) >24.9 kg/m²), and diet-related non-communicable diseases (NCDs). This coexistence is often referred to as the double burden of malnutrition, which is prevalent throughout the world and affects most of the global population at some stage during their life course (Popkin, Corvalan, & Grummer-Strawn, 2020). Micronutrients deficiencies has recently been studied as another form of undernutrition to emphasize the importance of vitamins and minerals on human health and setting priorities (UNICEF, 2019).

Globally, 149 million children (0-59 months of age) are stunted, 49.5 million are wasted, and 2.4 billion (one in three) people are obese or overweight despite abundance of better data, knowledge on what policy works, and strong political will among countries than before (Development Initiatives, 2021). In addition, the burden of preventable diet-related NCDs such as high blood pressure, diabetes and cancer is increasing (Afshin et al., 2019). Obesity or overweight is a modifiable risk factor of these NCDs. People
having diabetes increased from 108 million in 1980 to 422 million in 2016 (diabetes defined as adults aged ≥18 years with diabetes are defined as having fasting glucose ≥7.0 mmol/L, on medication for raised blood glucose, or with a history of diagnosis of diabetes) (B. Zhou et al., 2016). People affected by hypertension increased from 594 million to 1.1 billion in 2015 (hypertension defined as adults aged ≥18 years and older having systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥90 mmHg) (Bin Zhou et al., 2017). NCDs were responsible for 41 million (71%) of the world’s 57 million deaths in 2016, of which diet was one of the four leading risk factors, and the burden is greatest in low- and middle-income countries (LMICs), with 78% of all NCD deaths (WHO, 2018).

South Asia including Nepal is struggling with the triple burden of malnutrition: prevalent undernutrition, micronutrient deficiencies, and increasing overnutrition (Hossain et al., 2020; Popkin et al., 2020). South Asia bears about 40% of the global burden of stunting among children under five years of age (Aguayo & Menon, 2016). About one-third of the children are stunted in South Asia, which is comparable with stunting rates in sub-Saharan Africa (37%) and three times higher than those in East Asia and the Pacific (12%) or Latin America (11%) (Aguayo & Menon, 2016). Nepal has made a remarkable progress in reducing maternal and child undernutrition since mid-1990s (Zulfiqar A Bhutta et al., 2020; Cunningham, Headey, Singh, Karmacharya, & Rana, 2017), yet 36% of children under five years of age are stunted, 10% are wasted, and 27% are underweight (thin for their age) (Ministry of Health, New ERA, & ICF, 2017). In addition, inequities persist with the nutritional outcomes at the sub-national level: stunting is highest in the Mountains (41%) and wasting highest in the Terai
(southern plains) (19%) (K. C. et al., 2020). A steady decline (4% average annual rate of reduction) in stunting was observed among children under five years of age from 2001 to 2013, with virtually no decline from 2013 to 2016 (K. C. et al., 2020), whereas wasting has plateaued at ~10% since 2001 (Ministry of Health et al., 2017). Overnutrition among adults is increasing in Nepal: the overweight and obesity rates in women have increased from 14% in 2011 to 22% in 2016 (Ministry of Health et al., 2017; Ministry of Health and Population, New ERA, & ICF International, 2012). Compared to women, prevalence of overweight and obese men is less (17%). The overall prevalence of overweight children under five years of age seems stagnant at 1% from 2011 to 2016 (weight-for-height Z-score > 2 standard deviations (+2 SD) above the median of the reference population), however, the sub-population analysis shows that rate is increasing from 2011 to 2016 among certain population, for example, the rate has almost doubled among richer households (2% to 4%) (Ministry of Health et al., 2017). All these rates can be brought down to zero through a collaborative effort from different sectors involving different approaches, some of them being improving agriculture, production, diet, and dietary behaviors.

2.2 Food Consumption

Lack of diverse and healthy diet is one the major causes of preventable malnutrition and diet-related NCDs in LMICs (Li, Kim, Vollmer, & Subramanian, 2020). Diets are the outcomes of individuals food choices (behaviors) and are largely shaped by the wider food systems around them (Glopan, 2016; Turner et al., 2018b). Food systems comprise of the food supply chains (production, processing and packaging, storage, retails and markets), food environments, consumer behaviors, and diets, all of which are
inter-related and influenced by the political and economic, socio-cultural, demographic, environmental, and technological drivers (Downs, Ahmed, Fanzo, & Herforth, 2020; HLPE, 2014, 2017). Because of growing urbanization, globalization, and trade liberalization, food systems are more interconnected and complex than before (HLPE, 2017). Food systems are shifting from traditional to modern systems, which is linked with the increased availability and accessibility of new and diverse foods throughout the year, expanding consumers’ food choices, and thus modifying their dietary intakes. In addition, modern food systems have also introduced highly processed and ready-to-eat foods that are very low in nutritional content and cheaper than nutrient-rich foods. Lower-income consumers and people with busy work schedule are often lured to purchase these processed foods jeopardizing their health (Monteiro et al., 2018; Monteiro, Moubarac, Cannon, Ng, & Popkin, 2013).

Modern food systems are also being pushed towards being climate smart, healthy, and sustainable, yet are not being inclusive because some disadvantaged and vulnerable groups still have limited food choices under this system (IFPRI, 2020). Healthy diets are difficult for these groups to obtain because of several factors including their gender, ethnicity or caste, socio-economic status, rights to land, land tenure, and availability of resources such as seeds, fertilizers, and markets. In addition, people living in remote rural areas, urban slums or isolated areas like mountains, or small islands might have limited availability and accessibility of nutrient-rich foods partly due to dysfunctional food supply chains that cannot function well with perishable food items. Even with the limited resources, knowledge, and skills, people in rural communities produce foods for their own consumption, and sometimes sell to generate additional income.
The cost of foods, especially of nutrient-rich foods, is rising around the globe, which is limiting consumption of diverse foods among disadvantaged, marginalized, and poor population the most due to their limited-to-no income (FAO et al., 2020). For an example, a study done using data from 2011 International Comparison Program showed that most noncereal foods were relatively cheap in high-income countries, whereas healthy foods, especially most animal-sourced foods were generally expensive in lower-income countries (D. D. Headey & Alderman, 2019; World Bank, 2015). Because of limited food budget, when nutrient-rich foods are expensive, disadvantaged, and poorer households and individuals are left to buy cheaper foods, which are usually of low nutrients. Alternately, even when income of the poor increases, they are not inclined to allocate more food budget for purchasing nutrient-rich foods, rather they spend more on energy-dense foods or non-food items (Cirera & Masset, 2010; Laraia, Leak, Tester, & Leung, 2017). A study using Prospective Urban Rural Epidemiology (PURE) data from 18 countries from 2003 to 2013 showed that as the relative cost increased, consumption of fruit and vegetable among individuals decreased (Miller et al., 2016a). In addition, the same study revealed very low daily mean consumption of fruits and vegetables among individuals in lower-income countries compared to those in higher-income countries (2.14 vs 5.42 servings/day). Making nutrient-rich foods more affordable, accessible, and available is challenging especially for the disadvantaged and poor population as it requires co-ordination among several sectors like agriculture, industries and markets, culture, society, and economy. If one sectors fails to perform, others fail too, leaving the neediest population without nutrient-rich foods.
2.3 Nutrition-sensitive Agriculture

Achieving the goal of sustainable healthy diets for all amidst changing food systems and natural shocks like Covid-19 is still a challenge. Programs or interventions that directly or indirectly affect nutrition and health of people including poor, disabled, disadvantaged, women and children around the globe are required to achieve this goal. Traditionally, nutrition interventions or programs have targeted the immediate determinants of malnutrition (also called nutrition-specific interventions). Some examples of nutrition-specific interventions are adolescent, preconception, and maternal nutrition; dietary or micronutrient supplementation or fortification; complementary feeding and breastfeeding practices; disease prevention and management; and treatment of severe acute malnutrition (Marie T Ruel & Alderman, 2013). Global evidence, however, has shown that such nutrition-specific interventions alone are not enough to tackle with malnutrition (Zulfiqar A. Bhutta et al., 2013; Perez-Escamilla et al., 2018). In addition to nutrition-specific interventions, for reducing malnutrition at scale, we need nutrition-sensitive interventions, which target the underlying determinants of malnutrition and health such as agriculture and food security; nutrition education and counselling; water, sanitation and hygiene; social safety nets; women empowerment; early childhood development; and health and family planning services (Zulfiqar A Bhutta et al., 2020; Marie T Ruel & Alderman, 2013). Such nutrition-sensitive interventions can be leveraged as delivery platforms for nutrition-specific interventions. Recently, ‘nutrition-sensitive agriculture’ has been recognized in the literature as a new term (Balz, Heil, & Jordan, 2015; Marie T. Ruel et al., 2018), partly because of a global need for agriculture to promote health, nutrition, and sustainable healthy diets. In addition, agriculture has a
strong potential to influence the underlying determinants of nutrition outcomes, which comprise of food security, care, and health achieved through food availability, accessibility, dietary quality of foods, income, time management, and women empowerment.

A wide range of nutrition-sensitive agricultural interventions have been implemented in LMICs including homestead food production (HFP) programs, home vegetable gardens, biofortified crops, small animals, livestock, fisheries, dairy, and irrigation interventions as described in different reviews (Fiorella, Chen, Milner, & Fernald, 2016; Girard, Self, McAuliffe, & Olude, 2012; Masset, Haddad, Cornelius, & Isaza-Castro, 2012; Pandey, Mahendra Dev, & Jayachandran, 2016; Webb & Kennedy, 2014). In addition, several micro-interventions, small local projects that aim to generate tangible benefits at local level, such as school gardens, low-cost green house, beekeeping, guinea pig production, and conservation techniques have been implemented (Bernet et al., 2018). The studies have employed different methods and indicators, however, the overall evidence was that such agricultural interventions promote production diversity, dietary diversity, vitamin A intake among children, resulting in lower rates of wasting, anemia, and underweight when the interventions incorporate components of WASH and BCC (Marie T. Ruel et al., 2018). Among the interventions, HFP programs are popular and have been implemented throughout different countries for a long time.

2.4 Homestead Food Production

Homestead food production is an intervention that combines home gardens and animal husbandry along with behavior change communication strategies to achieve better
agricultural practices, nutrition, health, sanitation and hygiene practices, and activities that empower women in their households. HFP interventions started in the 1980s in Bangladesh, when 3.8% (>1 million) preschool-aged children suffered from night blindness, caused by severe vitamin A deficiency and can be prevented simply by increasing the consumption of vitamin a-rich fruits and vegetables that can be grown in home gardens (Ahmed, 2007). Therefore, in 1988, HKI conducted an assessment to explore existing gardening practices in north-west Bangladesh (Talukder et al., 2000). As the higher prevalence of children suffering lived in households without home gardens, in 1990, HKI conducted a pilot program reaching 1,000 households to explore the feasibility of promoting low-cost vegetable gardens combined with nutrition education and to identify constraints (Talukder et al., 2000). The results of the pilot program suggested that fruits and vegetables can be produced throughout the year with technical assistance and support. In addition, home gardening along with nutrition education had a positive impact on diversity of fruits and vegetables consumption among women and young children in Bangladesh (from mid-term evaluation of the pilot program in 1992) (Bloem et al., 1996). After learning from the pilot program, comprehensive evaluation, and planning exercise, HKI developed the ‘Bangladesh Homestead Gardening and Nutrition Education Program’. Since 1993 HKI started expanding the program within Bangladesh working in collaboration with local NGOs and the Government of Bangladesh. The program had the objectives of sustainable and diverse production of dark-green leafy vegetables and fruits throughout the year, and increased consumption of vitamin A-rich foods by women and young children. By 2003, the project was reaching more than 870,000 households, or half of the country’s subdistricts, and partnering with more than
70 local nongovernmental organizations and the government of Bangladesh (Iannotti, Cunningham, & Ruel, 2009). In addition, in 2002, realizing more efficiency and bioavailability of essential micronutrients, including vitamin A, iron, and zinc, and as the only source of vitamin B-12 from animal-sourced foods, HKI carried out a pilot project in Bangladesh, Nepal, and Cambodia to test the feasibility of including animal husbandry in its existing home gardening model (Iannotti et al., 2009).

At present homestead food production programs have been expanded and implemented several countries in Asia including Bangladesh, Cambodia, Indonesia, Nepal, and the Philippines and in Africa including Burkina Faso and Tanzania. During about 40 years since the commencement of HFP program, we have seen some impacts of the program. We see an increased production and consumption of nutrient-rich foods; diversified diets; and women empowerment (N. Kumar, Harris, & Rawat, 2015; Murty, Rao, & Bamji, 2016; D. K. Olney et al., 2016; Schreinemachers et al., 2015b; Schreinemachers, Patalagsa, & Uddin, 2016b). In addition, the places in Asia where the program has been implemented for a longer duration have decreased anemia prevalence among children aged from 6-59 months and their mothers (Girard et al., 2012; Michaux et al., 2019; A. Osei et al., 2016; A. K. Osei et al., 2015). As noted by Ruel et al., despite the positive impacts of the HFP program across different countries, additional research is needed to understand the effects of community-based nutrition-sensitive agriculture interventions like HFP on nutrition outcomes (Marie T. Ruel et al., 2018). There is a lack of evidence on long-term impacts of HFP programs or on the sustainability of these programs (for example, the practices and knowledge developed, or assets built by participants) once the funding ends. Additional work is required to understand the key
factors for the success of such HFP programs. For an example, we need to understand what interventions should be prioritized for which behaviors to improve maternal and child health involving nutrition-sensitive agriculture interventions (Harris-Fry et al., 2020). Moreover, understanding the production-related practices can help to improve implementation strategy and understand sustainability of HFP programs. Further evidence is required to assess the cost-effectiveness of programs that run for a long time (Schreinemachers et al., 2016b). For an example, a recent economic evaluation of enhanced homestead food production in Cambodia showed a positive monetary benefit due to increased agricultural production in addition to improved child health (Dragojlovic et al., 2020). The study, however, cautions the audience about the generalizability because the analyses in the study assume the program continues to be delivered by HKI (or a successor organization like Cambodian government), continued provision of training and agricultural inputs, no additional drop-outs, and the agricultural and economic conditions in Cambodia remain constant. Research is needed whether other age groups (like adolescent boys and girls, who are also nutritionally vulnerable) get more benefit from agriculture interventions than young children. Moreover, modification of the program that best suits the local context within a country is essential (for an example, promoting animal husbandry where growing fruits and vegetables is not possible due to harsh geographic terrain) so that the targeted population achieve the real benefits from the programs.

2.5 Homestead Food Production in Nepal

For over a decade in Nepal, HKI has been implementing HFP programs through Suaahara, a USAID-funded multi-sectoral integrated nutrition program. Suaahara,
currently implemented in 42 out of 77 districts has a specific intermediate result related to
HFP: *improved access to diverse and nutrient-rich foods by women and children*. To
achieve this result, HFP was launched in 2012, initially in 9 highly food insecure
districts. In 2013, 2014, and 2015, the program was scaled up and implemented in
additional 11, 5, and 16 districts respectively. In 2015 and 2016, during the transition
from *Suaahara I* (2011-2016) to *Suaahara II* (2016-2021), HFP program expanded to 2
additional *Suaahara II* districts in 2017, covering all *Suaahara* intervention districts. The
list of districts added in different years are presented in appendix B. As the HFP program
is targeted to disadvantaged and food insecure communities, the program is implemented
in all communities in some districts and a few communities in other districts. The HFP
program catchment area is shown in Figure 1.1.

*Suaahara’s* HFP program consists of interventions with Village Model Farmers
(VMFs) and household beneficiaries. A VMF (mostly woman) was selected from the
community, usually done in consultation with community level government bodies, such
as the Agriculture Development Divisions of municipalities, Agriculture Service Centers,
and District Agriculture Development Offices (from the then-pre-federalism in Nepal).
VMFs were selected if they: (1) have at least 1,000-1,200 square meters of irrigable,
flood-free land in close proximity to the home; (2) centrally located in the community,
surrounded by at least 20 households with mothers in the 1000-day period (i.e., the time
between conception and a child turning two years of age); (3) have at least one literate
and numerate household member; (4) the selected individual must be able to commit time
to engage in trainings, HFP meetings, agricultural labor, and other HFP activities; (5)
show interest to become a lead farmer in his/her community; and (6) with family
members supporting him/her to fulfill his/her roles and responsibilities as a VMF. Additionally, when possible, priority was given to mothers in the 1000-day period or female community health volunteers (FCHV). A 5-day VMF capacity building training was given to all VMFs as a foundation to enhance their knowledge and skills on technical aspects required for demonstration of food production techniques; and leadership development which is required to motivate 1000-day women in adoption of good agricultural practices. The trained VMFs received diverse vegetable seeds for three seasons (rainy, winter and dry) and 5 eight-week brooded chicks to establish demos on quality food production which aimed for spillover effects in community. In the last several years, opportunities for further capacity building of VMFs have been made available to those who have shown interest and readiness. These include trainings to specialize as a Local Resource Person (LRP) in vegetable or poultry production; business plan development and agricultural marketing; savings and credit groups; and others. In addition, selected VMFs were trained on climate-smart agriculture techniques to withstand nutritional sensitive shocks, stress, and uncertainties. Regarding other inputs, those VMFs who received business plan development and agricultural marketing or LRP in vegetable or poultry training and who were producing at a larger scale and market ready were provided with chicken coop building materials, weighing scales, vegetables crates, drip, garden pipes, cane, and plastic tunnels particularly to support them in marketing activities and building resilience.

A total of 5,686 VMFs were trained and given responsibility of establishing their model farm for demonstration purposes, providing ongoing technical assistance to beneficiary households and organizing the household beneficiaries into groups of about
16-25 members. Households were selected for inclusion in the HFP program if: (1) a 1000-day mother resided in the household at the time of the listing for the training; and (2) had at least 40 to 75 m² of land near the home. These households received a 2-day basic HFP training, distribution of 3 packets of seasonal seeds during the year immediately following the basic HFP training, distribution of 5 chicks, and linkage with a VMF for further inputs. In total, an estimated 114,000 HFP beneficiaries across 1001 VDCs of 42 districts have been reached. As the basic HFP training and seeds and chick distribution was a one-time effort per community, new households meeting these criteria at a later date were not direct beneficiaries of the HFP program. Such new households could have received seeds, chicks, and inputs from the households that have already enrolled in the program.

HFP is based on four programming principles: (1) Ensuring households’ access to diverse and nutrient-rich foods throughout the year; (2) Focusing production commodities—vegetables, egg, meat; (3) Promotion of low-cost but easy to adopt technologies; and (4) Empower smallholders farmers to build resilient and sustained household food production. Applying these principles, HFP is implemented at three different levels: household, community and structural levels. At household level the program targets 1000-day women with an aim to increase production and consumption of diverse nutrient-rich foods throughout the year. At the community level, the program establishes VMFs to support the household beneficiaries with agricultural practices and production, particularly when there is limited access to agricultural extension services and production inputs. In addition, the community level VMF approach aims for spillover effects in the community. At the structural level, the program operates at
agricultural/livestock offices at the VDCs and works to upscale and sustain HFP through mainstreaming and leveraging resources.

2.6 Agriculture, Livestock, and Policy Context in Nepal

2.6.1 Agriculture and Livestock

Nepal is a small landlocked country in south-Asia with a total area of 147,181 square km and population of about 30 million (Central Bureau of Statistics, 2019, 2022). It borders China in the north and India in the other directions. Geographically, Nepal is divided into three agro-ecological zones: northern mountains (consists 35% of the total land which has harsh rocky terrain out of which only 5% is cultivable), middle hills (42% of the total land which has rugged terrain with some fertile valleys, with only 20% of land being cultivable), and southern plains or Terai (23% of total land which is low, flat and fertile, out of which 41% is cultivable). Climate varies according to different elevations of the three zones. Climate in Mountain zone is sub-alpine to alpine: very cold, covered with snow for about half of the year, and scanty rainfall. In hills, climate is mostly temperate; and in Terai, climate is sub-tropical to tropical with hot and humid conditions most of the year. Amount of precipitation decreases as we move from east to west with increasing distance from the Bay of Bengal, origin of the monsoon, which is the major source of rain in the country. It is estimated that forests cover about 39% and agriculture covers about 30% of the total land in Nepal (K. Uddin et al., 2015).

More than 60% of the population in Nepal practice agriculture as their main occupation, and more women are involved in agriculture than men (70% vs 33%) (Ministry of Health et al., 2017). Generally, agriculture is of subsistence type with a mix
of staple crops, vegetables, and cash crops with some livestock. The agrarian structures in Nepal are characterized by a very small land holding scattered to different plots, where irrigation is usually either not available or seasonal (depending upon rainfall usually from monsoon). The dominating cropping patterns are cereal crops such as paddy (72%), wheat (57%), maize (64%), and millet (38%) (% of total grain production) and occupy 75% of the total cultivated land in Nepal (USAID, 2010). Winter vegetables are grown by 72% while summer vegetables are grown by 69% of the agricultural households (Central Bureau of Statistics, 2011). Livestock constitutes an integral part of Nepalese agriculture system, about 66% of the agricultural households keep cattle, 48% have buffalo, 65% have goat or sheep, and 54% have poultry (Central Bureau of Statistics, 2011). In addition, since each zone has different topography, climate, and rainfall, people adopt different agricultural practices. For an example, people in mountains rear goats, sheep, yaks, and grow crops like potato and buckwheat; in hills the major crops are maize, millet, some vegetables and fruits, and some livestock; in Terai the major crops are rice, wheat, maize, sugarcane, jute, some vegetables and fruits, and commercial livestock and fish farming. Nepal has undergone agricultural diversification towards high value crops and products (such as fruits and vegetables, spices and condiments, and livestock) although much needs to be done in terms of nutrition and food security (IFPRI, 2011). For an example, the share of cereals in terms of total value has decreased from 41% to 37% between 1981-2005 while high-value crops’ share rose from 54% to 59% during this same period (IFPRI, 2011).

Despite the diversification, agriculture suffers from low productivity as two-third of nation’s labor force employed in agriculture contributes about one-third gross
domestic product. In addition, size of farms is reducing, and number of subsistence family farms are increasing. The average farm size declined by 36% between 1961 to 2011 and the average land holding size was only 0.7 ha in 2011 (Central Bureau of Statistics, 2011). The landless or small-holders farmers, including women farmers are gradually abandoning agriculture in search for better opportunities within the country and abroad (Maharjan, Kochhar, Chitale, Hussain, & Gioli, 2020). Further, the scope agricultural mechanization is limited because of the difficult terrain and small-sized farms. Therefore, technological breakthroughs fitting the context of Nepal and diversification of crops, vegetables, and fruits are essential today to achieve food and nutrition security as proposed by various plans and polices in Nepal.

2.6.2 Policy Context

Nepal has been implementing a series of policies and plans since 1960s to improve food security and nutritional outcomes of adolescents, women, and children. National Planning Commission and different ministries, most importantly Ministry of Health, and Ministry of Agriculture and Livestock Development have played an important role in developing and implementing those policies. A detailed analysis of nutrition- and agriculture and livestock-related policies has been done in other documents published earlier (for an example, by United Nations Standing Committee on Nutrition (UNSCN)) (Pradhanang et al., 2015; UNSCN, 2013), however, we will present developments of the most relevant nutrition-related policies and plans in the following paragraphs.
The Ministry of Agriculture and Livestock Development (sometimes this ministry is divided into two independent ministries: The Ministry of Agriculture, and the Ministry of Livestock Development) is the premier body under government of Nepal to develop agriculture and livestock plans and polices and implement them in Nepal. This ministry has been working in Nepal not only to improve agriculture sector but also leverage agriculture to improve food and nutrition security through Food Security and Food Technology Division in Nepal. Since the first national five-year plan in 1965, modern agriculture development in Nepal has been started. Agriculture and livestock sectors were included as the major contributors to the national economy in the subsequent five-year plans. A long-term Agriculture Perspective Plan (1995-2014) was launched with the main objectives being to improve agriculture productivity, transform subsistence-based agriculture into a commercial one, and to expand employment opportunities. To reduce poverty and improve food security through a sustainable economic growth and commercialization of agriculture system, National Agriculture Policy, 2004 was developed (Ministry of Agriculture and Cooperatives, 2004). In 2010, the government of Nepal developed Nepal Agriculture and Food Security Country Investment Plan (2010-2014), which outlined ten agriculture and food security programs including agriculture research and development, and food safety and consumer protection (Sova & Chaudhury, 2013). In the same year, Nepal Agricultural Research Council (NARC) (an autonomous body, which was established in 1991 following the dissolution of the National Agricultural Research and Service Centre (NARSC), the body that had previously taken over agricultural research responsibilities from the then Ministry of Agriculture and Cooperatives in 1984) developed the Strategic Vision for Agricultural Research (2011–
One of the aims of the policy was to create and scale up technologies that contribute to food security. After the completion of Agriculture Perspective Plan, the government of Nepal developed the Agriculture Development Strategy (ADS) (2015-2035), a 20-year vision for the development of agriculture and livestock in Nepal (Ministry of Agricultural Development, 2014). This ADS serves as a major guideline that streamlines subsequent major strategies, periodic plans, and programs. This document has also identified the need for improved agricultural practices and animal husbandry practices to achieve higher productivity and household food security. Ensuring food and nutrition security is one of the major objectives, which is planned to achieve through implementation of three sub-programs (Food and Nutrition Security Program is the main program): Agriculture and Food Security Project; Food and Nutrition Security Plan of Action; and National Food and Nutrition Security Project.

Improving nutrition involves interventions in health and other sectors; therefore, plans and policies of not only agriculture and livestock but also of health, water and sanitation, education, gender, and social welfare and inclusion sectors are essential (Bach, Gregor, Sridhar, Fekadu, & Fawzi, 2020; Choufani, Jamaluddine, & Cunningham, 2019; Marshak, Young, Radday, & Naumova, 2020; Quisumbing et al., 2020; Reinhardt & Fanzo, 2014; World Bank, 2013). Understanding the importance of inter-relatedness of these sectors on nutrition and food security, the government of Nepal has multi-sectoral nutrition plan (MSNP) in effect. The first attempt at multi-sectoral nutrition programming was made through the Joint Nutrition Support Program (1989-1992). This program lacked engagement of sectors during its inception and thus could not become effective...
(Joshi & Chitekwe, 2019). To address this limitation, in 2004, the National Nutrition Policy was developed by the health sector, which was later revised in 2008 after reviewing the statistics published by Nepal Demographic and Health Survey, 2006. In 2011, the Nutrition Assessment and Gap Analysis (NAGA) was endorsed by the National Planning Commission, an apex advisory body of the Government of Nepal for formulating a national vision, periodic plans and policies for development by assessing resource needs and identifying funding sources. The NAGA identified strengths, weaknesses and gaps in nutrition programming and realized the need for a multi-sector approach resulting in the development of the first Multi Sector Nutrition Plan (MSNP-I, 2013-2017). After the completion of the MSNP-I and building on the lessons learned from it, the second MSNP (MSNP-II, 2018-2022) has been implemented. The MSNP-II is evidence informed, contains results based with realistic targets, and doable monitoring and evaluation planning. With the goal of “improved maternal, adolescent and child nutrition by scaling up essential nutrition-specific and sensitive interventions and creating an enabling environment for nutrition”, the current plan has emphasis on adolescents, pregnant and lactating mothers, emerging challenges of overweight and obesity, and gender empowerment and social inclusion (National Planning Commission, 2017). In addition, the missing elements in MSNP-I such as emergency nutrition, maternal and adolescent nutrition, mental health, and early childhood development have been included in MSNP-II (Joshi & Chitekwe, 2019; National Planning Commission, 2017).

Nepal is one among the few countries in the world that has “right to food” as the fundamental right of the citizens embedded in the Constitution of Nepal. In addition,
Nepal made its commitment to undertake Zero Hunger Challenge declared by the Rio+20 Conference on Sustainable Development held in Brazil in 2012. The Zero Hunger Challenge is a commitment to end hunger, eliminate all forms of malnutrition, and build inclusive and sustainable and resilient food systems (United Nations). Therefore, the Government of Nepal formulated the National Action Plan (NAP, 2016-2025) to ensure “right to food” and to achieve society free of hunger and malnutrition by 2025 by improving food and nutrition security (Ministry of Agricultural Development, 2016).

Developed in line with the Agriculture Development Strategy, the priorities of NAP are linked with MSNP-II and other poverty reduction frameworks related to food production, equitable distribution and effective utilization of food to maintain basic nutritional standards. The strategies for implementing NAP are enhanced production and productivity; increased investment in agriculture; physical infrastructure development; localization of food availability; agri-business development; increased employment opportunities; making agricultural occupation attractive for youths; support smallholder and landless producers with access to productive resources; safety net support for the vulnerable groups; and improved food governance (Ministry of Agricultural Development, 2016).

The different plans, policies and programs have included food and nutrition security as an important goal to accomplish national prosperity. Despite the progress made in productivity, infrastructure, food security, and poverty, agriculture and livestock sector needs improvement to incorporate agriculture-to-nutrition strategy, that is, having a nutrition goal when implementing agricultural interventions or programs. In addition, the ministries such as Education; Urban Development; Women, Children and Social
Welfare; and Local Development are observed as secondary ministries, and several others are unaware of their role in the MSNP and ADS (UNSCN, 2013). Therefore, coordination among different sectors is urgent to achieve the goal of national prosperity via achieving zero hunger, food and nutrition security.

2.7 Theoretical Frameworks

The proposed research is informed by the program theory framework conceptualized by HKI (Appendix A), which is adapted from the earlier versions of program theory developed by HKI and International Food Policy Research Institute (Haselow, Stormer, & Pries, 2016; Deanna K. Olney et al., 2013). Initially, the development of the framework for the homestead food production program began through discussions with key HFP program personnel at HKI office on how they perceived the program was operating to achieve the desired outcomes and impacts. Primary program components and hypothesized program impact pathways were identified and reasons that may affect the program delivery were discussed. Eventually, the final framework was developed (Appendix A). Three important program impact pathways identified to achieve improve maternal and child nutrition and health were: (1) availability and accessibility to diverse and nutrient-rich foods (production–consumption pathway); (2) increased income through the sale of surplus produce (production–income pathway); and (3) increased women empowerment through leveraging resources and improved knowledge (empowerment pathway).

The conceptual framework (Figure 2.2) for this research is adapted from the above-mentioned theoretical framework. The conceptual framework shows the pathways
of how participating in HFP program leads to adoption of improved production-related practices and production of diverse vegetables and poultry. VMFs are selected and trained so that they establish HFP groups, support the groups, and serve as community level agricultural extension workers. VMFs are Frontline workers who teach, train, and provide agricultural inputs and information to households for increased and diverse production of nutrient-rich foods throughout the year. The groups usually consist of about 16 to 25 mothers from the eligible households. Those mothers who get enrolled into the HFP program receive trainings, inputs, and support from the VMFs. The HFP program targets mothers because empowering women contributes to improving productivity from farms managed by women (Diirio, Seymour, Kassie, Muricho, & Muriithi, 2018). Women need trainings, inputs and information regarding agriculture to improve agricultural practices (Farinde & Ajayi, 2005). In addition, training and inputs improves women’s knowledge on agricultural practices, which increases agricultural productivity (Rivera-Ferre, 2008). The mothers utilize the gardening and poultry-raising knowledge, skills, and inputs from the program in establishing homestead garden and poultry coop. It is important to understand what the gardening and poultry-raising practices are that can lead to the improved production of vegetables and poultry. In the HFP program, because of the regular households’ visits and monitoring by VMFs and HFP program staffs, women are reinforced to improve agricultural productivity. This regular monitoring and support to the households might enable them to improve production of vegetables and poultry even the program has been implemented for a longer duration. Several other determinants such as participants’ age, education, occupation, residency level (alone or joint family), knowledge on agricultural practices and production, and involvement as an active
member of agriculture/livestock/fisheries producers group in the community; household caste/ethnicity; socio-economic status; size of agricultural land; anyone in the household received training on improved agriculture and poultry-raising practices; presence of ag/livestock group in the community; presence of Suaahara HFP group in the community; rural/urban areas; and agro-ecological zones.

2.8 Significance of the Study

Achieving zero hunger and better nutritional outcomes through sustainable healthy diets is possible by improving agricultural-to-nutrition knowledge and utilizing the barren lands by cultivating diverse and nutrient-rich foods throughout the year. In addition, we need to understand how nutrition-sensitive agricultural interventions work better for poor and disadvantaged population because they function differently than the average population (Banerjee & Duflo, 2012). This proposed research is significant because it will contribute to global agriculture-to-nutrition community by understanding whether promoting improved production-related practices translates into improved production of nutrients-rich foods. In addition, this research fosters our understanding of sustained engagement of the frontline workers. Understanding characteristics associated with frontline workers’ sustained participation and performance might inform nutrition-sensitive agriculture interventions at scale for improved service provision. Further, exploring farming practices among women smallholder farmers in disadvantaged communities, where the burden of malnutrition is high, might help policy makers to formulate and implement policies targeting local needs. The research is also significant in bringing in evidence that both gardening and poultry-raising practices can be promoted in tandem along with trainings and inputs for improved production of vegetables, egg, and
chicken. Finally, this research will inform global nutrition sector on role of small-scale agriculture and farming activities on healthy diets proposed by the EAT-Lancet Commission (Walter Willett et al., 2019).
Figure 2.1 *Suaahara* program’s HFP reach in Nepal
Figure 2.2 Conceptual framework on improving household vegetable and poultry production in Nepal

Covariates: Maternal level: age, education, occupation, residency level (alone, joint family), knowledge on agricultural practices and production, an active member of agriculture/livestock/fisheries producers group in the community
Household level: caste/ethnicity; socio-economic status, household food insecurity, size of agricultural land, anyone in the household received training on improved agriculture and poultry-raising practices
Community level: presence of ag/livestock group in the community, altitude
CHAPTER 3
METHODS

This research used quantitative methods to achieve the aims and answer the research questions using two different datasets on homestead food production program collected through Suaahara-II program in Nepal: (1) Suaahara-II VMF profile dataset (for aim 1) and (2) Suaahara-II survey (for aim 2).

3.1 Setting

Nepal is a landlocked country in south Asia. It is bordered by China to the north and India to the rest (Figure 3.1). Geographically, Nepal is divided into three agro-ecological zones: northern mountains, middle hills (42% of the total land which has rugged terrain with some fertile valleys, with only 20% of land being cultivable), and southern plains or Terai (23% of total land which is low, flat and fertile, out of which 41% is cultivable). Mountains, Hills, and Terai consists of 5%, 20% and 42% of cultivable land. More than 60% of the population in Nepal practice agriculture as their main occupation, and more women are involved in agriculture than men (70% vs 33%) (Ministry of Health et al., 2017). After the major governance reform in 2017, Nepal consists of 7 provinces, comprised of 77 districts and 753 municipalities (460 rural and 293 urban). Finally, there are 6,743 wards, the lowest administrative units. Previous village development committees (VDCs) were dissolved to form municipalities (rural or urban) and smaller ‘old’ wards were merged to form larger ‘new’ wards.
Nepal has increased its commitment to addressing nutrition and has emphasized on multi-sectoral approach to reduce malnutrition in the country. The Government of Nepal has been collaborating with various international non-governmental organizations like HKI to achieve the nutrition targets and goals. As a part of this collaboration, HKI has been implementing homestead food production program through *Suaahara-II* program in 42 districts out of 77 in Nepal, especially in the communities where food insecurity is high.

Dataset, sampling, and analyses for the two aims is described separately in the following paragraphs. We begin by explaining for aim 1 and then for aim 2.

3.2 Aim 1: Dataset, Sampling, and Analyses

3.2.1 Dataset

*Suaahara-II* VMF profile dataset was used to answer the research questions related to the aim 1.

3.2.2 Sampling and Recruitment

*Suaahara-II* began a Community Mapping Census (CMC) in 2017 to register all households residing in *Suaahara-II* intervention areas. VMFs, as residents of these communities, were also registered and this formed the starting point of the *Suaahara-II* VMF database to facilitate ongoing updating of VMF characteristics and tracking of program interventions for each VMF.
3.2.3 Data Collection

Suaahara-II program field staff were trained to collect the information. A cross-sectional survey of Suaahara VMFs was done from 2018 to 2019 to create a full roster of updated information on all VMFs selected by Suaahara since 2012. Suaahara staff, based in each of the 42 implementation districts, approached the VMFs to conduct face-to-face and phone interviews.

3.2.4 Sample Size

Out of 5,686 VMFs enrolled in the HFP program since 2012, complete information was available for 4,750 (83.5%), which were included in the analyses. The various reasons for loss to follow-up of the other 936 (16.5%) VMFs could be migration; leaving agricultural for other professions such as small businesses; death; and lack of interest to continue as a frontline worker (Government of Nepal, 2020b).

3.2.5 Data Analyses

All the analyses were done using Stata version 14.2 (StataCorp, Texas) creating sharable datasets and do files.

Outcome variable

To achieve aim 1, an outcome variable, “number of VMF activities”, was created based on VMF self-reported engagement in the following four activities: 1) conduct regular HFP group meetings, 2) discuss vegetable growing and chicken rearing practices with HFP group members, 3) engage in saving and credit activities in the HFP group, and 4) register the HFP group at any point with the local government, Agriculture and
Livestock Service Office, which requires the VMF to pro-actively collaborate with the local government and other stakeholders to make the group officially eligible for support from the local government. A score of 1 was given if a VMF reported to engage in the above activities, otherwise a score of 0 was given. Then, all the scores were summed to generate a total score, which represents the number of the activities. This outcome variable reflected performance of the VMFs, the higher the number of activities, the better was VMF’s performance. If the VMFs performed all their assigned activities together, household beneficiaries might receive support and guidance required for the improved production of vegetables, chicken, and eggs.

Co-variates

Potential socio-economic and demographic determinants were identified a priori based on earlier studies conducted in health care systems and nutrition-sensitive agricultural interventions in LMICs (Broaddus-Shea, Shrestha, Rana, Winch, & Underwood, 2020; Panday, Bissell, Teijlingen, & Simkhada, 2019; Rahman et al., 2010). Those constructed as categorical variables were: gender (male, female), caste (socially excluded, advantaged), being a female community health volunteer (no, yes), current 1000-day household (no, yes), residing in a disaster-prone district (no, yes), education (none, primary, secondary, and higher), equity quintile (1, 2, 3, 4, 5) to measure socio-economic status (Fry K., Firestone R., & Chakraborty N.M., 2014), years since the first VMF training (at least 4, 5, or 6 years ago), agricultural land size (at least 0.5 hectares, less than 0.5 hectares), and agro-ecological zone (mountains, hills, and Terai (plains)). Socially excluded caste groups consisted of Dalits, Muslims, and disadvantaged Janajatis while advantaged caste groups consisted of Brahmins/Chhetri, Gurung/Thakali, Newar,
and non-\textit{Dalit Terai} caste based on the caste/ethnicity defined by the Government of Nepal Health Information and Management System (Banstola & Banstola, 2015). Disaster-prone districts were determined based on a report by the Government of Nepal and included landslides, floods, wildfires, and lightning from 2008 to 2019 and also included the earthquake in 2015 (Government of Nepal, 2015, 2020a; Nepal Red Cross Society, 2019). Agricultural land size was categorized to compare subsistence and small commercial farmers versus smallholders, based on the classification used by the Government of Nepal (Ministry of Agricultural Development, 2014).

Continuous variables were age (in completed years), household size (in persons), a sum of the number of additional trainings beyond the basic introductory training (0-6), and a sum of the number of additional inputs received (0-6). Additional trainings considered were VMF capacity building, savings and credit and group management, business, local resource person, seed production, and post-harvest handling. Similarly, additional inputs received were those that went beyond the basic package of three packets of seeds and five to ten chicks: saplings of mango trees, banana, and papaya as per the agro-ecological zones, coop construction materials, farm materials, marketing promotion materials, hatchery machine, and solar dryer to improve existing traditional open drying practices, which often are not hygienic, safe, and time consuming (used mostly for radish, tomatoes, cauliflower, and broadleaf mustard).

\textbf{Analysis}

Ordinal logit regression was used to estimate adjusted odds ratios (AOR) and 95\% confidence intervals (CI) to test the association between the outcome variable, working actively as a VMF, and the determinants. First, we ran a proportional odds model (using
the command \texttt{ologit}) with the assumption of odds ratios being the same across categories. Second, since the proportional odds assumption may not strictly hold, we ran a generalized ordered logit model (using the command \texttt{gologit2}) that relaxes the proportional odds assumption (R. Williams, 2006; Richard Williams, 2016). We accounted for clustering and modeled the determinants identified \textit{a priori}.

Finally, to identify patterns of characteristics that distinguish VMFs working actively in the HFP program from those who are less active, a tree-based partitioning analysis, called classification and regression tree (CART) was used (Breiman, Friedman, Olshen, & Stone, 1984). In addition, CART analysis provides insight into possible interactions among the most useful variables for determining active engagement of the VMFs. A regression tree is constructed by recursively partitioning the data (Loh, 2002). Beginning with the whole sample as one group, the procedure selects from all variables the one variable and the one cutoff for that variable that best splits the group into 2 subgroups, maximizing differences on the outcome, in this case, number of VMF activities. At each stage, the binary partition that minimizes the total sum of the squared errors (SSE) is selected. Splitting stops if the fractional decrease in total SSE is less than a pre-specified value or if the sample size is too small. Eventually we come to a terminal node (also called leaf), where we make a prediction. This process results in a tree with a “root node” (full sample) from which “branches” emerge and “derivative nodes” at each point where a subgroup is further split until there are “terminal nodes”.

To obtain a regression tree, the “crtrees” command in Stata version 14.2 was used. Since all the variables were theoretically important in explaining the variation in the VMF activity, all the variables were included to construct regression trees. Since the
shape of the regression trees and coefficients were slightly different for each time the command was run, ten regression trees were created to observe the patterns of split and development of terminal nodes. For the final interpretation, a tree that was generally representative of the trees, simple, easily interpretable, and more generalizable was selected.

3.3 Aim 2: Dataset, Sampling, and Analyses

3.3.1 Dataset

*Suaahara-II* monitoring data collected in 2017 was used to answer the research question related to the aim 2.

3.3.2 Setting

*Suaahara*, a multi-sectoral program, has been implementing HFP program in 42 out of the 77 districts in Nepal for the improved access to diverse and nutrient-rich foods by women and children (Table 3.1). Therefore, HFP program has been promoting improved gardening and poultry-raising practices along with training and inputs to increase availability of diverse vegetables, egg, and chicken throughout the year. Implementation of nutrition-sensitive agriculture interventions like HFP increases the likelihood of promotion of knowledge on methods, practices, food production, consumption, and nutrition in the communities (Bernet et al., 2018). Although these interventions target specific households or individuals to improve knowledge on production-related practices, neighboring people might imitate the practices performed and seek support, resulting in a greater adoption of practices in the communities compared to where interventions have not been implemented (Boedecker et al., 2019;
Dillon, Bliznashka, & Olney, 2020). Some individuals get motivated to adopt the production-related practices while other do not, resulting in a greater variability in adoption of the practices. This variability helps to investigate whether engaging in more improved production-related practices translates to a greater production of quantity and diversity of nutrients-rich foods.

3.3.3 Sampling and Recruitment

A multi-stage stratified cluster sampling design was used to collect the data and has been described in detail elsewhere (HKI, 2018). In brief, the first-stage sampling units were districts (n=16). The second-stage sampling units were municipalities (1 urban and 1 rural per district, excluding the district headquarter municipality n=32). The third-stage sampling units were new wards (3 per municipality, n=96). The fourth-stage sampling units were old wards (2 per new ward, n=192) (because of larger size of new wards data collection was logistically challenging, therefore, old wards were selected). The final-stage sampling unit was households with children under 5 years of age (19 per old ward, n=3648). The first four stages were conducted using probability proportional to size techniques. For the fifth stage, households with a child under 5 years and a mother living in the same house were selected randomly.

In the selected old wards, a listing of households was conducted which contained information about the name of the household head, whether the household has a child under 5 years or not, and if yes, the name of the mother of the child. From the list of all households, a list of households having a child under 5 years of age and the child’s mother residing together was prepared and 19 households were randomly selected for inclusion in the survey, by drawing names from a hat. If there was an insufficient number
of eligible households in the selected old ward, the same procedures were followed in the adjoining old ward to select the remaining required households.

3.3.4 Data Collection

The present study utilized data collected from the Suaahara-II monitoring survey in 2017. We used only the monitoring data collected in 2017 because the subsequent rounds of monitoring data collected in 2018 and 2019 lacked detailed information on production-related practices. In addition, the earlier monitoring data collected from 2011 to 2016 was led by a different organization than HKI and the monitoring system was different. A local Nepali firm, New Era, recruited a team of 105 field staff, including 6 quality controllers, 20 supervisors, and 59 enumerators for the data collection. All the field staff were trained to familiarize with the survey objectives and tools. The training included detailed explanations of the survey objectives and design including multi-stage sampling and selection of households and appropriate informed consent and interviewing methods. Every question of every module was discussed, and skip patterns, filtering, and probing techniques were explained. Enumerators were also trained in how to collect data using android phones, using ‘Ona’, an offline data collection application. Face-to-face interviews were done. Once the data was collected and reviewed by the supervisor, the enumerator synced the data to the Ona server. During data collection, field team supervisors regularly reviewed the data collected by the enumerators prior to syncing the data to the online database.

According to the type of questionnaires (such as household, mothers, child, etc.) response from multiple respondents were recorded in the survey. For this study, information on homestead food production was collected from mothers of children under
five years old since the homestead food production component of *Suahara-II* program has been targeting mothers. Information on households and communities was collected from the household heads or mothers (if they were the household heads).

### 3.3.5 Sample Size

*Suahara-II* monitoring survey collected information on homestead food production among households in addition to information on maternal and child health, dietary practices, empowerment, and other household information. Among the 3,643 households enrolled in the survey, 3,635 had complete information, therefore, were used as our final sample for the analyses.

### 3.3.6 Data Analyses

All the analyses were done using Stata version 14.2 (StataCorp, Texas) creating sharable datasets and do files.

**Exposure variables**

We had two separate exposure variables:

(a) *Improved gardening practices score:* Gardening practices were determined by assessing the following five activities, a few of which were observed by the interviewers, and some were reported by the respondents: (i) growth of vegetables in a dedicated plot; (ii) growth of vegetables within a fenced area; (iii) use of organic manure in the last agricultural season; (iv) use of bio-pesticide in the last agricultural season; and (v) use of irrigation. If the respondents reported practice of the activities, a score of 1 was given for each, otherwise 0 was given. Then, we
created a total score by summing the individual scores for each practice (range 0 to 5). Higher score reflected better gardening practices, which could result in improved production of vegetables. Among the ideal and improved gardening practices promoted by the HFP program in the communities of Nepal, these were the ones included in the survey. Adopting only one practice might not suffice for improved and diverse production of vegetables. A household was recommended to perform all of these practices depending upon the type of vegetables grown, which could result in increased availability and productivity of diverse vegetables throughout the year.

(b) Improved poultry-raising practices score: Poultry-raising practices were determined by assessing the following seven activities and generating a score of these practices: (i) use of chicken coop for rearing chicken; maintaining facilities and conditions of coop; (ii) fresh air and ventilated space; (iii) facility of clean water and pot; (iv) clean or fresh chicken feed and pot; (v) proper security; (vi) deworming chickens; and (vii) vaccinate against New Castle Disease. If the respondents reported practice of the activities, a score of 1 was given for each, otherwise 0 was given. Then, we created a total score by summing the individual scores for each practice (range 0 to 7). Higher score reflected better poultry-raising practices, which could result in improved production of chicken and eggs. In addition to the promotion of gardening practices, improved poultry-raising practices have been promoted in the communities. Among the ideal and improved poultry-rearing practices promoted by the HFP program, these practices were the ones included in the survey. Adopting only one practice might not suffice for
increased egg and meat production. Therefore, the HFP program recommends households to adopt all of these practices if they want increased production of eggs and chicken.

**Outcome variables**

This study had four separate outcome variables: vegetable production diversity, vegetable production quantity, egg production, and chicken production.

*(a) Vegetable production diversity:* Based on the major nutrients present in the vegetables and adapted from the groupings used in a study of homestead food production program in Bangladesh (Schreinemachers et al., 2016b), we grouped 35 vegetables produced into five types: dark-green leafy vegetables (DGLV), other vitamin A-rich vegetables, beans and pulses, roots and tubers, and other vegetables. This grouping can be related to dietary diversity for children 6 to 23 months of age as guided by World Health Organization (WHO, 2007) and for women as guided by Food and Agriculture Organization (FAO, 2010). Respondents were asked which vegetables they grew in the 12 months. If they reported production of any vegetables from each vegetables group, a score of 1 was given, otherwise 0 was given. For an example, if the mothers reported growth of broadleaf mustard or pumpkin shoot, a score of 1 was given to the vegetable group, “dark-green leafy vegetables”. Then, we summed (range 0 to 5) the individual scores for each vegetable group to create vegetable production diversity score. A list of the vegetables and their groups is provided in the Table 3.2.
(b) *Quantity of vegetable production*: Quantity of vegetable production was assessed by measuring kilograms (kg) of vegetables produced by the households in the last 12 months. Respondents were asked how much (in kg) of vegetables they harvested during the last 12 months.

Poultry production was assessed by measuring the quantity (in numbers) of chicken and eggs produced by the households separately.

(c) *Egg production*: Respondents were asked how many eggs were produced in the last one month.

(d) *Chicken production*: Respondents were asked how many chickens the households had at the time of survey. Information on three different chicken types: improved (e.g., New Hampshire, Black Australorp); local (e.g., *Sakini*, *Ghanti Khuile*); and boilers/layers was obtained. For the analyses, regardless of the types of the chicken raised, the numbers were combined.

**Covariates**

To account for the potential confounding, we identified variables *a priori*, based on published literature and knowledge of the local context and intervention being studied. We grouped the variables by level into individual (maternal), household, and community. Maternal characteristics were age of mothers (in years), education (none, primary, secondary, and higher), major occupation (agriculture and non-agriculture), residency type (whether a mother lived alone, lived with her husband and children, and lived in a nuclear family), mother’s knowledge on agricultural practices, and whether mother was an active member of agriculture/livestock/fisheries producers group in the community (including marketing groups and *Suaahara* HFP group). Mothers’ knowledge on
agricultural practices was constructed as a score by summing all the scores based on responses to each question the mothers were asked (such as “What are some potential advantages of having a homestead garden?”; “What are some potential advantages of producing small animals such as chickens or goats?”). Several options were present for each question, which were not read to the mothers. If they answered the options a score of 1 was given, if they say don’t know or others, a score of 0 was given.

Household-level variables were caste/ethnicity (socially advantaged versus socially disadvantaged), socio-economic status, total land size (measured in hectares), household food insecurity, and anyone in the household received training on improved agriculture and poultry-raising practices. Socially excluded caste groups consisted of Dalits, Muslims, and disadvantaged Janajatis while advantaged caste groups consisted of Brahmins/Chhetri, Gurung/Thakali, Newar, and non-Dalit Terai caste based on the caste/ethnicity defined by the Government of Nepal Health Information and Management System. Socio-economic status was determined using equity quintile (Fry K. et al., 2014). Household food insecurity was measured using the household food insecurity access scale by using the one developed by Food and Nutrition Technical Assistance project (Coates, Swindale, & Bilinsky, 2007). Training on improved agricultural practices included: (i) field crop selection or rotation; (ii) improved seeds or crop varieties; (iii) pest management and identification; (iv) soil improvement (fertility and composting); (v) home gardening (other); (vi) water conservation and use for agriculture; (vii) improved post-harvest food storage practices. Training on improved poultry-raising practices included: (i) treating chicken disease, such as Newcastle; and (ii) chicken breeding and husbandry.
Community-level variables were presence of any agriculture/livestock/fisheries group in the community (including marketing groups), and altitude (measured in meters).

Analyses

The association between improved gardening practices score and vegetable production diversity was tested by using linear mixed-effects regression models (command “mixed” in Stata). The fixed-effects portion of the regression model consisted of improved gardening practices score and the potential confounders identified a priori and the random-effects portion consisted of districts.

The association between improved gardening practices score and vegetable production quantity (in kg) was tested by using linear mixed-effects regression models (command “mixed” in Stata). Before this, we used a square root transformation to make the distribution of vegetable production quantity less skew and reduce the potential influence of large values. The fixed-effects portion of the regression model was the transformed quantity and potential confounders identified a priori and the random-effects portion specified districts.

The association between improved poultry-raising practices score and egg and chicken production was tested separately by using left-censored regression models (command “tobit” in Stata). The distribution of the outcome variables, number of egg and chicken production in the past one month, had more than half zeros. The values at zero were treated as censored. The regression model was adjusted for the potential confounders identified a priori and clustering at district level using “vce” command.
3.4 Protection of Human Subjects

Ethical approval to conduct the annual monitoring survey and community mapping census was obtained from Nepal Health Research Health Council, an autonomous body under the Ministry of Health and Population in Nepal. Since the secondary data for this research was used, it was exempt from ethical approval from the Institutional Review Board, University of South Carolina.

Informed consent forms were used for to explain the purpose of data collection, approximate duration, right to refuse to participate, right to withdraw during participation, right to confidentiality and anonymity and agreement to record the discussions for both data collection exercises. Before conducting the interviews, field enumerators read the informed consent. Then a written consent (signed by the participants) or oral consent (for some VMFs when face-to-face interviews were not possible) was obtained, if the participants agreed to the interviews. Participants’ privacy and confidentiality were maintained during data collection and de-identified datasets was used for this study.

3.5 Data Management

New Era, the institution contracted for data collection, received the monitoring survey data via the Ona server. Key New Era and Suaahara-II staff had access to the uploaded data. New Era staff would download the data from the Ona server, check the quality and consistency of the data, and provided feedback to enumerators, as needed. All corrections were recorded by the New Era staff who consequently updated the database and informed the Suaahara-II team. After completing the initial data cleaning and
verification the cleaned raw data files were sent to the Suahara-II monitoring and evaluation team for further data cleaning. The team further cleaned the data and generated required variables. A data sharing agreement was signed between Helen Keller International and University of South Carolina to receive the datasets in Stata version 14. Datasets are stored in at least two password protected computers in University of South Carolina.
Figure 3.1 Map of Nepal (Source: Wikimedia Commons)
Table 3.1 List of districts and years when HFP program was implemented in these districts in Nepal

<table>
<thead>
<tr>
<th>Year of HFP implementation</th>
<th>Districts</th>
<th>Number of districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Rasuwa, Dolakha, Taplejung, Sankhuwasabha, Manang, Mustang, Bajura, Bajhang* and Darchula</td>
<td>9</td>
</tr>
<tr>
<td>2014</td>
<td>Accham, Dadeldhura*, Baitadi, Doti and Nuwakot</td>
<td>5</td>
</tr>
<tr>
<td>2017</td>
<td>Panchathar and Dhading*</td>
<td>2</td>
</tr>
</tbody>
</table>

*Districts included in the present study (n=16).
Table 3.2 List of vegetables produced in the households reported by the respondents during the past year

<table>
<thead>
<tr>
<th>Food groups</th>
<th>Individual vegetables and poultry (from our data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark-green leafy vegetables</td>
<td>Broadleaf mustard, Fenugreek, Colocasia, lettuce, coriander, kangkong, Swiss chard, cress, amaranth, spinach, pumpkin shoots</td>
</tr>
<tr>
<td>Other vitamin A-rich vegetables</td>
<td>Carrot, orange flesh sweet potato, pumpkin, tomato</td>
</tr>
<tr>
<td>Beans and pulses</td>
<td>Pea, broad bean, four-season bean, cowpea</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>Yam, potato</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>Chili, Onion, Radish, cauliflower, squash, turnip, cabbage, brinjal, sponge gourd, bottle gourd, bitter gourd, snake gourd, garlic, chayote squash, balsam apple, broccoli, okra, asparagus, other</td>
</tr>
</tbody>
</table>
CHAPTER 4
RESULTS

4.1 Manuscript 1

Sustaining Agriculture and Nutrition Interventions: Determinants of Continued Engagement of Village Model Farmers in Nepal

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Abstract

Background: In homestead food production (HFP) programs, village model farmers (VMFs), after training, implement agriculture and nutrition activities to improve household knowledge and practices. Little evidence exists on what enables VMFs to remain actively engaged and for impacts to be sustained.

Objective: To examine determinants of active engagement of VMFs, at least 4 years post training, in an HFP program in Nepal.

Methods: We used cross-sectional program monitoring data, collected from 2018 to 2019, among 4,750 VMFs of Suaahara, a multi-sectoral nutrition program. We assessed whether respondents registered their HFP group with the local government, conducted regular group meetings, discussed vegetable growing and chicken rearing practices with group members, or engaged in saving and credit activities in their HFP group. The outcome variable counted in how many of these four activities the VMF engaged. Potential socio-economic and demographic determinants were identified a priori and adjusted for clustering in ordinal regression models.

Results: On average, VMFs engaged in 1.4 activities. Having attended primary or secondary school (AOR=1.39), being a female community health volunteer (AOR=1.27), being from an advantaged caste/ethnic group (AOR=1.34), and receiving additional trainings (AOR=1.56) and inputs (AOR=1.31) were associated with more active engagement of VMFs.

Conclusion: VMFs that received more training and inputs were more likely to remain actively engaged. Female community health workers, people from higher caste/ethnic
groups, and those with primary or secondary education were more likely to remain active VMFs and could be targeted for this role in a HFP program to lead to sustained impact.

**Introduction**

Consumption of nutrient-rich foods such as vegetables, fruit, eggs, and meat in low- and middle-income countries (LMICs) remains a challenge. Low consumption of such nutrient-rich foods can be attributed to poor knowledge of the importance of such foods, lack of skills in producing these foods, consumption preferences, habitual dietary practices, high prices, limited access to markets, lack of availability, and food policies (Bodor et al., 2008; Development Initiatives, 2020; Miller et al., 2016b; Turner et al., 2018a). Low consumption of nutrient-rich foods has been linked to malnutrition, including stunting (low height for age), wasting (low weight for age), underweight, anemia, vitamin and mineral deficiencies, and overweight or obesity and diet-related non-communicable diseases, especially among vulnerable populations, including women and children under 5 years of age (Dietz, 2017; Gibson et al., 2012; Kjøllesdal et al., 2016; Prentice, 2018; Tzioumis et al., 2016; R. Uddin, Lee, Khan, Tremblay, & Khan, 2020). Globally, 149 million children (0-59 months of age) are stunted, 49.5 million children are wasted, 40.1 million children are overweight, and 2.4 billion (one in three) people are obese or overweight, most of which could have been prevented by improved diets (Development Initiatives, 2020).

Globally, efforts are being made to improve diets and reduce food insecurity, in part by pushing for transformations of food systems to be climate-smart, healthy, and sustainable (International Food Policy Research Institute, 2020). A healthy diet, however,
is unreachable for millions of people, particularly those who are disadvantaged and vulnerable with limited access to high-quality food and resources such as land, seeds, and fertilizers (International Food Policy Research Institute, 2020). People living in remote rural areas, urban slums, or isolated areas like mountains or small islands might have limited availability and accessibility of nutrient-rich foods partly due to dysfunctional food supply chains (Development Initiatives, 2020). In addition, the cost of nutrients-rich food is often high and when coupled with low incomes affect disadvantaged, marginalized, and poor populations the most (D. D. Headey & Alderman, 2019; Miller et al., 2016b; World Bank, 2015). Even the most affordable diet proposed by the EAT-Lancet commission costs about US$3 per day in 2011 (W. Willett et al., 2019), of which the largest share (31%) is the cost of fruit and vegetables (Hirvonen et al., 2020).

In South Asia, despite the relatively rapid increase in the gross output value of milk and milk products, meat, and fruit and vegetables as compared to that of cereals (Rashid, Ahmed, & Rana, 2020), the issues of availability, accessibility, rising food prices, and affordability of nutrient-rich foods still prevail. Food value chains (i.e., complex interactions between multiple actors from production to markets to consumption) of nutrient-rich foods are struggling to meet the need of people, and there is a disconnect between farmers and consumers leading to low consumption of healthy foods (Donovan & Gelli, 2019; Ssennoga, Mugurusi, & Oluka, 2019). For example, markets in Nepal are concentrated in urban areas, and lack of markets in rural settings leave people with no options for purchasing nutrient-rich foods. The limited markets that exist in remote areas sell mainly staples, oils, sugar, spices, and condiments that people buy frequently and that do not spoil quickly. In addition, the increasing number of small
stores in rural areas have exposed local people to low-nutrient value foods like noodles, savory snacks, cookies, and sugar-sweetened beverages (Schreinemachers et al., 2021). Furthermore, the higher cost of nutrient-rich foods compared to cereals in Nepal has exacerbated challenges related to the promotion of high-quality of diets (Akhter et al., 2018; Biehl et al., 2016; Tamrakar et al., 2020).

One important way to deal with issues of poor availability, affordability, and accessibility of nutrient-rich foods is to promote households’ own production of these foods. Helen Keller International (HKI) has been working since the 1980s to promote homestead gardens and small-animal production in several Asian and African countries (HKI, 2013). HKI’s homestead food production (HFP) programs empower women from poor households in Africa and Asia with agriculture, nutrition, and health education, as well as agricultural resources needed to produce their own nutritious foods that are rich in vitamins, minerals, and proteins (Marie T. Ruel et al., 2018). HKI’s HFP program in Nepal has been implemented for several decades, including through a USAID-funded integrated nutrition program known as Suaahara (2011-2023). One of Suaahara’s four specific intermediate results on the path to reducing undernutrition among mothers and children is to improve access to diverse and nutrient-rich foods by women and children. Suaahara’s HFP component is vital to achieving this result and improving food security and nutritious diets particularly in disadvantaged communities throughout Nepal. Initially launched in 9 highly food-insecure districts in 2012, Suaahara’s HFP interventions expanded to include food-insecure areas in 42 of Nepal’s 77 districts by 2019 (Figure 4.1).
HFP programs rely on village model farmers (VMFs), who, once trained, become community-level extension workers or change agents. So, VMFs are intermediaries between program implementers and intended beneficiaries in the communities. They promote garden to plate (agriculture to nutrition) activities within households in their communities. VMFs provide agricultural inputs and information to households in their communities and teach through demonstration so that the households can increase and diversify their production to ensure availability of nutrient-rich foods throughout the year. In the Suaahara program, VMFs are also referred to as frontline workers as they directly provide services to households in their communities (United States Agency for International Development, 2015). When individuals become VMFs, they get the opportunity to become community role models and can receive respect from peers and local government; they receive inputs, trainings, travel, and related per-diems; and their families benefit from changes in production and income-generation from agriculture based on their learnings and program engagement.

HKI collaborated with local farmers and community organizations to establish one VMF per ward (rural and urban municipalities, in the post-federalism context since 2017) (The Himalayan Times, 2017), the smallest administrative unit in Nepal at the start of Suaahara. From 2013 to 2017, a total of 5,686 residents of the communities were selected to be VMFs, in consultation with community government bodies. Selected VMFs needed to be from households meeting these criteria: (1) have at least 1,000-1,200 square meters of irrigable, flood-free land in close proximity to the home; (2) centrally located in the community, surrounded by at least 20 households with mothers in the 1000-day period (i.e., the time between conception and a child turning two years of age);
(3) have at least one literate and numerate household member; (4) the selected individual must be able to commit time to engage in trainings, HFP meetings, agricultural labor, and other HFP activities; (5) show interest to become a lead farmer in his/her community; and (6) with family members supporting him/her to fulfill his/her roles and responsibilities as a VMF. Additionally, when possible, priority was given to mothers in the 1000-day period or female community health volunteers (FCHV). All VMFs received a five-day initial training to enhance their knowledge and skills on technical aspects required for demonstration of food production techniques and leadership development which would be required for them to motivate households to adopt good agricultural practices. Following this, the trained VMFs received diverse vegetable seeds for three seasons (rainy, winter, and dry) and five to ten eight-week brooded chicks to establish demonstration areas at their homes on quality food production which aimed to create spillover effects in their communities. During the last several years, opportunities for further capacity building of VMFs have been made available to those who have shown interest and readiness. These included training to specialize as a Local Resource Person in vegetable or poultry production, business plan development and agricultural marketing, savings and credit groups, and others. In addition, to withstand shocks, stress, and uncertainties, select VMFs were trained on climate-smart agriculture techniques, for example polyhouse or tunnel agriculture, solar pump irrigation, and multi-use water system that meets both domestic and agricultural needs. Regarding additional inputs, some VMFs who received additional training and who were producing at a larger scale for the market were provided with chicken coop building materials, weighing scales,
vegetables crates, drip irrigation, garden pipes, and plastic tunnels to support their farms to be more resilient and to sell produce in local markets.

HFP programs and other nutrition-sensitive agricultural interventions have been associated with, and in part have been successful at, improving outcomes like dietary diversity (in Bangladesh, Cambodia and Nepal) (Dulal et al., 2017; Schreinemachers et al., 2020; Schreinemachers et al., 2017; Schreinemachers et al., 2015a; Verbowski et al., 2018), household food security (in Bangladesh and Nepal) (Bushamuka et al., 2005; A. Osei et al., 2017; Talukder et al., 2010), hemoglobin levels (in Bangladesh, Burkina Faso, Cambodia, Nepal, and Philippines) (Kennedy et al., 2017; A. Osei et al., 2017; Talukder et al., 2010), and reduced wasting among children (in Burkina Faso and Zambia) (N. Kumar et al., 2018; D. K. Olney, Pedehombga, Ruel, & Dillon, 2015). Quasi-experimental studies done in Bangladesh focused on long-term impacts of nutrition-sensitive agricultural interventions on vegetable production and consumption three years after the intervention ended (Baliki, Brück, Schreinemachers, & Uddin, 2019; Schreinemachers et al., 2015a; Schreinemachers, Patalagsa, & Uddin, 2016a).

These studies are essential but understanding participation and performance of frontline workers in nutrition-sensitive agricultural interventions is also important. To deliver nutrition-sensitive agricultural interventions at scale, frontline workers at the community levels can be the most convenient and sometimes only point of contact (Lehmann & Sanders, 2007). As in health care interventions, community-level volunteers and frontline workers are the backbone of nutrition-sensitive agricultural interventions, who serve as channels of information, resources, and counseling in the communities. Various studies of health systems in LMICs have shown that individual, socio-cultural,
and contextual characteristics might be associated with performance of frontline workers and uptake of services (Crispin et al., 2012; M. Kok et al.; M. C. Kok et al., 2017; M. C. Kok et al., 2015). In addition, a systematic review of 140 studies performed among frontline workers working in primary health care settings in LMICs showed that incorporation of frequent supervision and continuous training in intervention designs can strengthen frontline worker performance (M. C. Kok et al., 2015). Similarly, to scale up nutrition services, frontline nutrition workers play an important role, but in LMICs, they often lack high-quality training, are given outdated training and assessment materials, and lack development of broader skills that would enable them to work as part of multisectoral team (S. Gillespie, Haddad, Mannar, Menon, & Nisbett, 2013; Pelletier et al., 2012). A study using behavior change communication to promote infant and young child feeding practices in Bangladesh showed that frontline health workers maintained good knowledge and fidelity to the intervention even one year after the intervention (Avula et al., 2013). A dearth of evidence exists, however, on what and how different demographic, socio-economic, programmatic, and contextual characteristics influence participation and performance of frontline workers in nutrition-sensitive agricultural interventions. Several studies on nutrition-sensitive agricultural interventions that mobilized community-level volunteers or frontline workers have been conducted, but these lack information on participation and performance. Low participation and inadequate performance of frontline workers in turn harms service quality (Rowe, De Savigny, Lanata, & Victora, 2005). Thus, understanding the determinants influencing VMFs’ sustained participation and performance in programs is needed to improve service provision and to inform nutrition-sensitive agricultural interventions.
Similar to health care interventions, if nutrition-sensitive agricultural interventions are to be made sustainable, frontline workers must have fully mastered knowledge, skills, and practices, and have the motivation to continue using the learned practices (Rahman et al., 2010). Sustainability of nutrition-sensitive agricultural interventions largely depends on frontline workers as their acquired knowledge and skills can be utilized even after outside support concludes. A recent review showed a lack of evidence on sustainability of any impacts of nutrition- and gender-sensitive programs or on sustainability of practices adopted or assets accrued by participants after these programs conclude (Marie T. Ruel et al., 2018). Another study conducted in Bangladesh showed that nutritional gains of a home garden intervention were fully sustained for at least three years after support ended (Baliki et al., 2019). A study conducted to assess sustainability of a nutrition-sensitive agriculture project in an urban setting showed that participants’ nutrition knowledge remained unchanged while improved practices of growing vegetables and raising chickens promoted by the project declined after 18 months of project completion (Nordhagen, Thiam, & Sow, 2019). Therefore, a cognizant selection of frontline workers is necessary to sustain program participation and in turn benefits for both the frontline workers and participants.

To our knowledge, limited studies have assessed factors that are associated with continued VMF engagement and sustainability of nutrition-sensitive agricultural interventions (Baliki et al., 2019; Nordhagen et al., 2019). Therefore, the aim of this study was to examine socio-economic, demographic, and programmatic determinants associated with active engagement of VMFs several years after being selected as VMFs in Nepal.
Methods

Data collection

A cross-sectional survey of Suaahara VMFs was done in 2018 and 2019 to create a full roster of updated information on all VMFs trained by Suaahara since 2013. Suaahara staff, based in each of the 42 implementation districts, conducted face-to-face interviews (or phone interviews, when an in-person interview was not possible) with VMFs. Out of a total of 5,686 Suaahara VMFs to approach, 4,750 (83.5%) were reached.

Outcome variable

An outcome variable was created based on VMF self-reported engagement in the following four activities: 1) conduct regular HFP group meetings, 2) discuss vegetable growing and chicken rearing practices with HFP group members, 3) engage in saving and credit activities in the HFP group, and 4) register the HFP group at any point with the local government, Agriculture and Livestock Service Office, which requires the VMF to pro-actively collaborate with the local government and other stakeholders to make the group officially eligible for support from the local government. The variable, “number of VMF activities” was created by summing the number of these activities (0-4) in which the VMF engages. A value of zero indicates VMFs not performing any of the four activities and reflects no participation in the program (49%, n= 2,307). Among the four activities, 44% (n= 2,079) of the VMFs conducted regular HFP group meetings, 38% (n= 1,783) discussed vegetable growing and chicken rearing practices with HFP group members, 46% (n= 2,187) engaged in saving and credit activities in the HFP group, and
16% (n=751) registered the HFP group at any point with the local government, Agriculture and Livestock Service Office. The sum measure reflects performance of the VMFs, the higher the number of activities, the better was VMF’s performance. If the VMFs perform all their assigned activities, household participants are more likely to receive the support and guidance required for them to improve their production of vegetables, chicken, and eggs.

**Covariates**

Potential socio-economic and demographic determinants were identified *a priori* based on earlier studies conducted in health care systems and nutrition-sensitive agricultural interventions in LMICs (Broaddus-Shea et al., 2020; Panday et al., 2019; Rahman et al., 2010). Those constructed as categorical variables were: gender (male, female), caste (socially excluded, advantaged), being a female community health volunteer (no, yes), current 1000-day household (no, yes), residing in a disaster-prone district (no, yes), education (none, primary, secondary, and higher), equity quintile (1, 2, 3, 4, 5) to measure socio-economic status (Fry K. et al., 2014), years since the first VMF training (at least 4, 5, or 6 years ago), agricultural land size (at least 0.5 hectares, less than 0.5 hectares), and agro-ecological zone (mountains, hills, and Terai (plains)). Socially excluded caste groups consisted of Dalits, Muslims, and disadvantaged Janajatis while advantaged caste groups consisted of Brahmins/Chhetri, Gurung/Thakali, Newar, and non-Dalit Terai caste based on the caste/ethnicity defined by the Government of Nepal Health Information and Management System (Banstola & Banstola, 2015). Disaster-prone districts were determined based on a report by the Government of Nepal and included landslides, floods, wildfires, and lightning from 2008 to 2019 and also included
the earthquake in 2015 (Government of Nepal, 2015, 2020a; Nepal Red Cross Society, 2019). Agricultural land size was categorized to compare subsistence and small commercial farmers versus smallholders, based on the classification used by the Government of Nepal (Ministry of Agricultural Development, 2014).

Continuous variables were age (in completed years), household size (in persons), a sum of the number of additional trainings beyond the basic introductory training (0-6), and a sum of the number of additional inputs received (0-6). Additional trainings considered were VMF capacity building, savings and credit and group management, business, local resource person, seed production, and post-harvest handling. Similarly, additional inputs received were those that went beyond the basic package of three packets of seeds and five to ten chicks: saplings of mango trees, banana, and papaya as per the agro-ecological zones, coop construction materials, farm materials, marketing promotion materials, hatchery machine, and solar dryer to improve existing traditional open drying practices, which often are not hygienic, safe, and time consuming (used mostly for radish, tomatoes, cauliflower, and broadleaf mustard).

**Statistical analysis**

Adjusted odds ratios (AOR) and respective 95% confidence intervals (CI) were estimated to test associations between the outcome variable and the hypothesized determinants using an ordinal logit regression model as the outcome variable is ordinal. First, we ran a proportional odds model (using the command `ologit` in Stata) with the assumption of odds ratios being the same across categories. Second, since the proportional odds assumption may not strictly hold, we ran a generalized ordered logit
model (using the command *gologit2* in Stata) that relaxes the proportional odds assumption (R. Williams, 2006; Richard Williams, 2016). We accounted for clustering and modeled the determinants identified *a priori*.

Finally, to identify patterns of characteristics that distinguish VMFs working actively in the HFP program from those who are less active, a tree-based partitioning analysis, called classification and regression tree (CART) was used (Breiman et al., 1984). In addition, CART analysis provides insight into possible interactions among the most useful variables for determining active engagement of the VMFs. A regression tree is constructed by recursively partitioning the data (Loh, 2002). Beginning with the whole sample as one group, the procedure selects from all variables the one variable and the one cutoff for that variable that best splits the group into 2 subgroups, maximizing differences on the outcome, in this case, number of VMF activities. At each stage, the binary partition that minimizes the total sum of the squared errors (SSE) is selected. Splitting stops if the fractional decrease in total SSE is less than a pre-specified value or if the sample size is too small. Eventually we come to a terminal node (also called leaf), where we make a prediction. This process results in a tree with a “root node” (full sample) from which “branches” emerge and “derivative nodes” at each point where a subgroup is further split until there are “terminal nodes”.

To obtain a regression tree, we used the “crtrees” command in Stata version 14.2. Since all the variables were theoretically important in explaining the variation in the VMF activity, we included all the variables to construct regression trees. Since the shape of the regression trees and coefficients were slightly different for each time we ran the command, we created ten regression trees to observe the patterns of split and
development of terminal nodes. For the final interpretation, we selected a tree that was generally representative of the trees, simple, easily interpretable, and more generalizable.

All analyses were performed using Stata version 14.2 (StataCorp, Texas).

**Ethical approval**

Ethical approval for the study was provided by the Nepal Health Research Council as part of Suaahara’s monitoring system ethical review (Reg. No: 197/2018). Participants were briefed about the purpose of the study. Participation was voluntary and consent was obtained before the start of each interview.

**Results**

Almost all VMFs were women (95%) and their mean age was 35 years (Table 4.1). Two-fifths of the VMFs had some or completed secondary education. More than half of the VMFs were from advantaged caste groups and two-fifths were residing in households in the lowest equity quintile. The majority of VMFs were smallholder farm households (land size < 0.5 ha). About half of the VMFs lived in disaster-prone districts (52%) and in the hills of Nepal (54%). The mean number of additional trainings and inputs received were 1.3 and 0.7, respectively.

Among the VMFs who participated in the study and were interviewed, the mean number of VMF activities was 1.4 (Table 4.1). The mean number of VMF activities for those who had higher education was 1.6. If the VMF was a FCHV, the mean number of VMF activities was 1.7 compared to 1.4 if she was not. VMFs from advantaged caste groups performed a higher average number of VMF activities (1.5) than VMFs from
disadvantaged caste groups (1.3). The mean number of activities of VMFs from poor and middle equity quintile households was 1.5 and that of VMFs from the richest households was 1.2. If the total agricultural land size was less than 0.5 hectares (near landless farmers), the average number of VMF activities was 1.4 compared to 1.5 if they had at least 0.5 hectares of agricultural land.

In the adjusted proportional odds model, several socio-economic and demographic covariates were associated with people continuing to work actively as a VMF after their training (Table 4.2). Compared to VMFs without education, those that had completed primary and secondary education had 1.39 times greater odds of being more active (i.e., performing more activities). If the VMF was a FCHV, the odds of being more active were 1.27 times higher. VMFs from advantaged caste groups had 1.34 times the odds of being more active as compared to VMFs from disadvantaged caste groups. VMFs living in disaster-prone districts had higher odds of being more active than VMFs not living in disaster-prone districts. For each number of additional trainings and inputs received, VMFs were more likely to be active.

To examine the odds ratios for each threshold (i.e., number of activities), we also ran a generalized ordinal logistic regression model that estimated the associations of socio-economic and demographic determinants at each threshold (Table 4.3). This showed the odds ratios for VMFs: with higher education, from advantaged caste groups, trained at least 5 or 6 years ago (as compared to 4 years), and living in disaster-prone areas were greater with performing higher number of VMF activities than lower number of activities.
The first variable selected was the number of additional trainings received and was split as the VMFs who received only one additional training and those who received more than one additional training (Table 4.4). The important variables in predicting VMF activity score among those VMFs receiving only one additional training were number of additional inputs received, agro-ecological zones, year since receiving first VMF training, and disaster-prone district. The mean VMF activity score for those with one additional training, some inputs received, and received their first training six years ago was 2.2 compared to 1.5 for those received their trainings five years or less. If the VMFs had one additional training, no additional inputs received, and residing in hills or Terai, the mean VMF activity score was 0.8. VMFs living in disaster-prone districts, in mountains, did not receive any additional inputs, and received only one additional training had a mean activity score of 1.9 (Figure 4.1).

The important variables that predicted VMF activity score among those receiving more than one additional training included more trainings received, agro-ecological zone, whether the VMF is an FCHV, and education. VMFs who received four or more additional trainings had a mean VMF activity score of 2.9. When the VMFs had less than three additional trainings, residing in mountains or hills, and were also working as FCHVs, the mean VMF activity score was 2.7. If the VMF was not working as a FCHV but had education level of primary or above, residing in mountains or hills, and receiving less than three additional trainings, the mean VMF activity score was 2.1 compared to 1.4 if the VMF did not have any education. The regression tree explained 15.1% of the variance in VMF activity score (Figure 4.1).
Discussion

This study examined several demographic, socio-economic, and programmatic determinants of sustained participation and performance of frontline workers in a nutrition-sensitive agricultural program that has been implemented in Nepal for more than a decade. Higher levels of education, being a female community health volunteer, being from an upper caste household, and having received more additional trainings and inputs were associated with more active participation among VMFs retained in the HFP program. These determinants can be important considerations, along with ways to support more vulnerable households from disadvantaged caste, less educated, and poorer households, for successful implementation at a large scale and sustainability of nutrition-sensitive agricultural interventions.

Education has been shown to be important for uptake of new information and improved performance among frontline workers. Improved nutrition education competencies among agriculture extension workers enable them to perform well in multi-sectoral nutrition policy contexts (Shimali, Najjingo Mangheni, & Kabahenda, 2021). In this study, higher education of VMFs was associated with higher chances of working actively and performing more VMF activities in the program. The most likely reason is that education enables the VMFs to better understand the importance of their work so that they continue to be actively involved in the program. In addition, they might better inculcate the knowledge and better utilize the inputs than those that are less educated, which can further enhance their active participation and performance. For community health volunteers in Nepal and Bangladesh, education is one of the key reasons for their continued willingness to work as volunteers and has enabled them to take care of
themselves as well as other households in their communities (Panday et al., 2019; Panday, Bissell, van Teijlingen, & Simkhada, 2017; Rahman et al., 2010). In addition, community health volunteers’ lower level of education can limit them to communicate the importance of healthcare messages to mothers (Panday et al., 2019). In Uganda, less educated community health workers have lower community acceptance (Okuga, Kemigisa, Namutamba, Namazzi, & Waiswa, 2015), which necessitates to have a higher level of education among community frontline workers to have sustained participation and better performance in their jobs. Interventions, however, should also focus on methods to improve knowledge and enhance skills of the less educated frontline workers in the communities so that the interventions can be effective in achieving their targeted goals and reducing social inequities.

FCHVs have been Nepal’s frontline health workers in communities, promoting health, delivering health services, and collecting and reporting data to health facilities since the 1980s (Khatri, Mishra, & Khanal, 2017). FCHVs have a remarkable reputation in supporting the health system and making health interventions successful (Kandel & Lamichhane, 2019). Our study showed VMFs who were also FCHVs were more likely to work actively as a VMF and performed more activities. People know and trust FCHVs because they are from the same communities (Kandel & Lamichhane, 2019; Lee, 2020), which make them favorable conduits to implement interventions. FCHVs seem able to apply their experience in community engagement and use this to successfully implement the HFP program (Betron et al., 2020; Panday et al., 2017). For instance, it may be a natural next step for FCHVs to share information and resources for how to grow and consume nutritious foods, as they are already promoting good health and nutrition.
practices including dietary diversity in the communities. Nevertheless, program implementers should be cautious not to overburden FCHVs (Khatri et al., 2017).

Caste has been a long-standing organizing system for Nepalese society and the values and relationships among caste groups are deep-rooted in the local society (Bennett, Dahal, & Govindasamy, 2008; Jodhka, 2018; Pal, 2020). People from disadvantaged caste groups such as Dalits face constraints such as lack of land and can be bonded laborers for better-off households reflecting social inequities (Broaddus-Shea et al., 2020; Malik, 2019). To empower the vulnerable groups including the poor, less educated, and socially disadvantaged groups and reduce the inequity gap, it is crucial for nutrition-sensitive programs to understand the social constraints and challenges they face and provide them motivation, additional trainings, and inputs as per their needs. Selecting people from disadvantaged caste groups as frontline workers may mean that the desired outcomes will take longer to achieve (Schaaf, Warthin, Freedman, & Topp, 2020). In Uganda, low social status of community health workers hindered their delivery of services to communities (Okuga et al., 2015). To achieve the targeted goals, programs should help to gradually overcome the constraints and challenges by increasing self-confidence, timely supervision, and support from program staff to the workers having low social status.

Training events are meant to empower and increase the VMFs’ knowledge and skills, particularly related to agriculture, whereas the provision of inputs help them to convert this into practice, especially when there are resource constraints. Suaahara-II provided some VMFs with additional trainings related to savings and credit and group management, business development, becoming a local resource person, seed production,
and post-harvest handling. In addition, VMFs in the same communities were also
connected with each other, and with supply-chain actors and the local government. These
activities along with the trainings and post training follow-ups might have enhanced
VMFs’ confidence level, which enabled them to work more actively. Since those VMFs
who were already actively working might have become more interested and have sought
additional trainings and inputs, a reverse causality might be a possibility, warranting a
careful interpretation of the results. Similarly, frontline farmer volunteers in Kenya
believed that capacity building through training workshops and provision of training
materials were important for improving their performance (Kiptot & Franzel, 2015).
Likewise in Bangladesh and Vietnam, training along with supervision and mass media
exposure contributed to improved frontline health workers’ service delivery by enhancing
their knowledge and motivation (Nguyen, Kim, Tran, Menon, & Frongillo, 2019). In
some locations in Nepal, local governments mobilize trained VMFs as agricultural
facilitators to disseminate climate-smart agricultural practices. In addition, in some
districts, trained VMFs are serving as community frontline workers for other
development projects working to improve access to technologies, inputs, credit, and
extension services. Such recognition of Suaahara VMFs might also motivate them to
continue working actively and perform well as VMFs in their communities.

To our knowledge, this is the first study, to analyze the socio-economic and
demographic determinants of VMFs remaining actively engaged in a nutrition-sensitive
agriculture program multiple years after being selected and trained. The cross-sectional
nature of the data allows us to identify associations but does not firmly prove causality
between covariates and outcomes. Social desirability bias might have affected the
responses, particularly regarding whether the VMFs remained engaged in all the four activities. As we did not have information among those who dropped out of the program, we could not explore the reasons why those VMFs did not continue to work. In addition, being a rapid survey, we collected information only on the four activities performed by the VMFs to measure “active participation”, which, although perhaps not adequate, indicates that by performing these activities a VMF continues to actively serve households in the communities. In-depth study of these activities, for example, how long the meetings were held, which topics were discussed more frequently, and how VMFs resolved the issues arose during the meetings might have helped to understand their active participation in the HFP program. In addition to the study of activities performed by the VMFs, future research on sharing information on homestead food production and demonstrating in real field set-ups to the households by the VMFs could help understand their sustained and active engagement into large nutrition-sensitive agriculture interventions. Finally, several factors including time and resource allocation, social support, and irrigation which were not measured and might have been associated with the outcome (Broaddus-Shea et al., 2020).

Further research using in-depth interviews might be helpful to understand how the identified determinants help to sustain the participation and performance of frontline workers in nutrition-sensitive agricultural interventions including HFP. Future research on how and over what period of time the frontline workers use their knowledge and skills honed by participating in nutrition-sensitive agricultural interventions might help understand sustainability of such interventions (Baliki et al., 2019; Nordhagen et al., 2019). Additional research is necessary to measure the performance of the VMFs from
the participants’ perspectives, what they think about the services provided by the VMFs in their communities, as done by a study among health care frontline workers in Bangladesh and Vietnam (Nguyen et al., 2019). Examining the determinants of working actively as VMFs might not be sufficient for implementation and scale up of nutrition-sensitive interventions since implementers and government are also interested in the cost and benefits of involving VMFs in nutrition-sensitive agriculture programs, which necessitates cost effectiveness studies of such programs.

**Conclusion**

Higher education, advantaged caste, being a female community health volunteer, and receiving additional trainings and inputs are characteristics associated with frontline workers’ sustained participation and performance, which, in turn, are necessary for improved service provision and to inform nutrition-sensitive agricultural interventions at scale. Program implementers need to consider these characteristics along with the physical and social environment while designing nutrition-sensitive agricultural interventions at scale. In addition, methods are necessary to improve knowledge and enhance skills of less educated, poorer, and disadvantaged caste frontline workers in the communities so that the interventions can be effective in reaching wider population and reducing social inequities. Selecting community health volunteers or frontline workers as VMFs might help achieve intervention goals as these people are more likely to continue to participate and remain actively engaged in the program many years after the training. Besides the basic training and inputs given to the VMFs at the start of the intervention, the provision of additional training and inputs at regular intervals contributes to VMFs remaining actively engaged.
References


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Miller, V., Yusuf, S., Chow, C. K., Dehghan, M., Corsi, D. J., Lock, K., . . . Mente, A. (2016). Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: findings from the Prospective Urban Rural
Epidemiology (PURE) study. *Lancet Glob Health*, 4(10), e695-e703. doi: [https://doi.org/10.1016/S2214-109X(16)30186-3](https://doi.org/10.1016/S2214-109X(16)30186-3)


qualitative study. *BMC Health Serv Res, 17*(1), 623. doi:10.1186/s12913-017-2567-7


Table 4.1 Characteristics and descriptive analyses of active engagement of village model farmers enrolled in a Homestead Food Production program and currently present in the communities in Nepal

<table>
<thead>
<tr>
<th></th>
<th>Number of VMFs</th>
<th>%/mean (SD)</th>
<th>Number of VMF activities</th>
<th>P-value&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td>4750</td>
<td>1.4 (1.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Female</td>
<td>4509</td>
<td>94.9</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>241</td>
<td>5.1</td>
<td>1.1 (1.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (in years)</strong></td>
<td>4750</td>
<td>(10.0)</td>
<td>-0.01</td>
<td>0.462&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No education</td>
<td>1161</td>
<td>24.4</td>
<td>1.2 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Some/completed Primary (grades 1-5)</td>
<td>1133</td>
<td>23.9</td>
<td>1.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Some/completed Secondary (grades 6-10)</td>
<td>1936</td>
<td>40.8</td>
<td>1.5 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Some/completed higher education</td>
<td>520</td>
<td>10.9</td>
<td>1.6 (1.6)</td>
<td></td>
</tr>
<tr>
<td>VMF also a Female Community Health Volunteer</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No</td>
<td>4048</td>
<td>85.2</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>702</td>
<td>14.8</td>
<td>1.7 (1.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Caste</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Advanced</td>
<td>1923</td>
<td>40.5</td>
<td>1.5 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Disadvantaged</td>
<td>2827</td>
<td>59.5</td>
<td>1.3 (1.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Equity quintile</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.013</td>
</tr>
<tr>
<td>Poorest</td>
<td>1898</td>
<td>40.0</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1301</td>
<td>27.4</td>
<td>1.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>960</td>
<td>20.2</td>
<td>1.5 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>490</td>
<td>10.3</td>
<td>1.4 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Richest</td>
<td>101</td>
<td>2.1</td>
<td>1.2 (1.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Current 1000-day household</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.797</td>
</tr>
<tr>
<td>No</td>
<td>4336</td>
<td>91.3</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>414</td>
<td>8.7</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Total agricultural land size</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.607</td>
</tr>
<tr>
<td>At least 0.5 hectares</td>
<td>1030</td>
<td>21.7</td>
<td>1.5 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Less than 0.5 hectares (near landless farmers)</td>
<td>3720</td>
<td>78.3</td>
<td>1.4 (1.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Household size (range:1-42)</strong></td>
<td>4750</td>
<td>7.1 (3.8)</td>
<td>-0.04</td>
<td>0.003&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Having been selected as a VMF at least</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4 years ago</td>
<td>1853</td>
<td>39.0</td>
<td>1.3 (1.4)</td>
<td></td>
</tr>
<tr>
<td>5 years ago</td>
<td>1637</td>
<td>34.5</td>
<td>1.3 (1.6)</td>
<td></td>
</tr>
<tr>
<td>6 years ago</td>
<td>1260</td>
<td>26.5</td>
<td>1.7 (1.6)</td>
<td></td>
</tr>
<tr>
<td>VMF lives in disaster-prone districts</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No</td>
<td>2299</td>
<td>48.4</td>
<td>1.2 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Agro-ecological zones</td>
<td>Yes</td>
<td>2451</td>
<td>51.6</td>
<td>1.6 (1.6)</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----</td>
<td>------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>Terai (Plains)</td>
<td></td>
<td>672</td>
<td>14.2</td>
<td>1.0 (1.4)</td>
</tr>
<tr>
<td>Hills</td>
<td></td>
<td>2581</td>
<td>54.3</td>
<td>1.4 (1.5)</td>
</tr>
<tr>
<td>Mountain</td>
<td></td>
<td>1497</td>
<td>31.5</td>
<td>1.7 (1.6)</td>
</tr>
<tr>
<td>Number of additional trainings received score (range: 0-6)</td>
<td>4750</td>
<td>1.3 (0.9)</td>
<td>0.26</td>
<td>&lt;0.001b</td>
</tr>
<tr>
<td>Number of additional inputs received score (range: 0-6)</td>
<td>4750</td>
<td>0.7 (0.9)</td>
<td>0.19</td>
<td>&lt;0.001b</td>
</tr>
</tbody>
</table>

Abbreviations: SD, standard deviation

a ANOVA test

b Pairwise correlation coefficient and corresponding p-value
Table 4.2 Associations between socio-economic and demographic determinants and active engagement of village model farmers in a Homestead Food Production program in Nepal, results from ordinal logistic regression model (N=4750)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Number of VMF activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR (95% CI)</td>
</tr>
<tr>
<td>Gender (female, male=ref)</td>
<td>1.48 (0.92, 2.40)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.01 (1.00, 1.02)</td>
</tr>
<tr>
<td>Education (no education=ref)</td>
<td></td>
</tr>
<tr>
<td>Some/completed Primary (grades 1-5)</td>
<td>1.39 (1.10, 1.75)</td>
</tr>
<tr>
<td>Some/completed Secondary (grades 6-10)</td>
<td>1.39 (1.11, 1.76)</td>
</tr>
<tr>
<td>Some/completed higher education</td>
<td>1.29 (0.98, 1.70)</td>
</tr>
<tr>
<td>VMF also an FCHV (no=ref)</td>
<td>1.27 (1.08, 1.50)</td>
</tr>
<tr>
<td>Caste (disadvantaged=ref)</td>
<td></td>
</tr>
<tr>
<td>Advantaged</td>
<td>1.34 (1.12, 1.60)</td>
</tr>
<tr>
<td>Equity quintile (poorest=ref)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0.99 (0.84, 1.18)</td>
</tr>
<tr>
<td>Middle</td>
<td>0.96 (0.76, 1.21)</td>
</tr>
<tr>
<td>Rich</td>
<td>0.92 (0.69, 1.23)</td>
</tr>
<tr>
<td>Richest</td>
<td>0.77 (0.48, 1.21)</td>
</tr>
<tr>
<td>Current 1000-day household (no=ref)</td>
<td>1.02 (0.86, 1.21)</td>
</tr>
<tr>
<td>Total agricultural land size (less than 0.5 hectares=ref)</td>
<td></td>
</tr>
<tr>
<td>At least 0.5 hectares</td>
<td>0.95 (0.82, 1.10)</td>
</tr>
<tr>
<td>Household size</td>
<td>1.00 (0.98, 1.02)</td>
</tr>
<tr>
<td>Having been selected as a VMF at least (4 years ago=ref)</td>
<td></td>
</tr>
<tr>
<td>5 years ago</td>
<td>1.00 (0.64, 1.56)</td>
</tr>
<tr>
<td>6 years ago</td>
<td>1.59 (0.66, 3.86)</td>
</tr>
<tr>
<td>VMF lives in disaster-prone districts (no=ref)</td>
<td>1.43 (0.99, 2.08)</td>
</tr>
<tr>
<td>Agro-ecological zones (Terai (Plains)=ref)</td>
<td></td>
</tr>
<tr>
<td>Hill</td>
<td>1.48 (0.58, 3.80)</td>
</tr>
<tr>
<td>Mountain</td>
<td>1.58 (0.86, 2.91)</td>
</tr>
<tr>
<td>Number of additional trainings received</td>
<td>1.56 (1.33, 1.83)</td>
</tr>
<tr>
<td>Number of additional inputs received</td>
<td>1.31 (1.11, 1.54)</td>
</tr>
<tr>
<td></td>
<td>0 vs 1, 2, 3, &amp; 4 activities</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Gender (female, male=ref)</td>
<td>1.64 (1.03, 2.63)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.00 (0.99, 1.01)</td>
</tr>
<tr>
<td>Education (no education=ref)</td>
<td></td>
</tr>
<tr>
<td>Some/completed Primary (grades 1-5)</td>
<td>1.42 (1.08, 1.86)</td>
</tr>
<tr>
<td>Some/completed Secondary (grades 6-10)</td>
<td>1.38 (1.07, 1.79)</td>
</tr>
<tr>
<td>Some/completed higher education</td>
<td>1.33 (0.98, 1.81)</td>
</tr>
<tr>
<td>VMF also an FCHV (no=ref)</td>
<td>1.25 (1.03, 1.52)</td>
</tr>
<tr>
<td>Caste (disadvantaged=ref)</td>
<td></td>
</tr>
<tr>
<td>Advantaged</td>
<td>1.25 (1.04, 1.50)</td>
</tr>
<tr>
<td>Equity quintile (poorest=ref)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1.04 (0.86, 1.26)</td>
</tr>
<tr>
<td>Middle</td>
<td>0.97 (0.74, 1.27)</td>
</tr>
<tr>
<td>Rich</td>
<td>0.96 (0.66, 1.38)</td>
</tr>
<tr>
<td>Richest</td>
<td>0.71 (0.48, 1.05)</td>
</tr>
<tr>
<td>Current 1000-day household (no=ref)</td>
<td>1.01 (0.84, 1.23)</td>
</tr>
<tr>
<td>Total agricultural land size (less than 0.5 hectares=ref)</td>
<td></td>
</tr>
<tr>
<td>At least 0.5 hectares</td>
<td>1.00 (0.81, 1.23)</td>
</tr>
<tr>
<td>Household size</td>
<td>1.00 (0.98, 1.03)</td>
</tr>
<tr>
<td></td>
<td>5 years ago</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>0.82 (0.49, 1.35)</td>
</tr>
<tr>
<td>6 years ago</td>
<td>1.63 (0.67, 3.95)</td>
</tr>
<tr>
<td>VMF lives in disaster-prone districts</td>
<td>1.10 (0.72, 1.67)</td>
</tr>
<tr>
<td>(no=ref)</td>
<td></td>
</tr>
<tr>
<td>Mountain</td>
<td>1.24 (0.44, 3.49)</td>
</tr>
<tr>
<td>Hill</td>
<td>1.37 (0.6, 3.15)</td>
</tr>
<tr>
<td>Number of additional trainings received</td>
<td>1.55 (1.30, 1.84)</td>
</tr>
<tr>
<td>Number of additional inputs received</td>
<td>1.48 (1.21, 1.82)</td>
</tr>
</tbody>
</table>
Table 4.4 Summary of variables from a regression tree for active engagement of village model farmers in a Homestead Food Production program in Nepal

<table>
<thead>
<tr>
<th>Number of additional trainings received</th>
<th>Number of additional trainings received</th>
<th>Number of additional inputs received</th>
<th>Agro-ecological zone</th>
<th>Duration since first VMF training received</th>
<th>VMF lives in a disaster-prone district</th>
<th>Education</th>
<th>FCHV</th>
<th>Active engagement of VMFs, Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than one</td>
<td>&gt;3.5 (4 to 6)</td>
<td>-</td>
<td>-</td>
<td>6 years</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>2.9</td>
</tr>
<tr>
<td>More than one</td>
<td>≤3.5 (2 to 3)</td>
<td>-</td>
<td>Mountain or Hills</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>-</td>
<td>1 or more</td>
<td>-</td>
<td>≤5 years</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>2.2</td>
</tr>
<tr>
<td>More than one</td>
<td>≤3.5 (2 to 3)</td>
<td>-</td>
<td>Mountain or Hills</td>
<td>-</td>
<td>Primary or above</td>
<td>-</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>One</td>
<td>-</td>
<td>None</td>
<td>Mountain</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td>More than one</td>
<td>≤3.5 (2 to 3)</td>
<td>1 or more</td>
<td>-</td>
<td>≤5 years</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>1.5</td>
</tr>
<tr>
<td>More than one</td>
<td>≤3.5 (2 to 3)</td>
<td>-</td>
<td>Terai</td>
<td>-</td>
<td>None</td>
<td>-</td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>One</td>
<td>-</td>
<td>None</td>
<td>Mountain</td>
<td>-</td>
<td>None</td>
<td>-</td>
<td>No</td>
<td>1.4</td>
</tr>
<tr>
<td>One</td>
<td>-</td>
<td>None</td>
<td>Hills or Terai</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>One</td>
<td>-</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.8</td>
</tr>
</tbody>
</table>
Figure 4.1 Regression tree for active engagement of village model farmers in a Homestead Food Production program. The sample size in each node includes only those in the learning sample, ~50% of the total sample size in the root node. FCHV, Female Community Health Volunteer.
4.2 Manuscript 2

Use of improved gardening and poultry-raising practices is associated with increased vegetable and poultry production in Nepal.²

Abstract

Objective: Nutrition-sensitive agriculture interventions often intend to improve household production of vegetables, fruits, and small livestock by promoting improved gardening and poultry-raising practices along with low-cost but easy to adopt technologies. We investigated whether use of improved gardening and poultry-raising practices was associated with increased household vegetable and poultry production among households in Nepal.

Methods: We used cross-sectional monitoring data collected from 3,635 households in 16 districts in 2017 through Suaahara-II, an integrated nutrition program in Nepal. Improved gardening and poultry-raising practice scores were created by summing improved gardening and poultry-raising activities promoted by the program. Vegetable production was assessed using: (i) a vegetable production diversity score (0 to 5), generated by categorizing 35 vegetables produced into 5 groups and summing them: dark-green leafy vegetables (DGLV), other vitamin A-rich vegetables, beans and pulses, roots and tubers, and other vegetables, and (ii) quantity produced (kg). Poultry production was assessed by counting the number of chickens and eggs produced in the households in the month prior to data collection. Linear mixed-effects and left-censored regression models were used to examine the associations between the practices and production.

Results: Average vegetable production diversity, quantity of all vegetables produced, number of eggs produced, and number of chickens produced were 3, 197 kg, 6, and 8, respectively. Vegetable production diversity and quantity of different groups of vegetables were greater for those households performing a greater number of improved
gardening practices, as well as egg and chicken production and poultry-raising practices respectively. Engaging in a higher number of improved poultry-raising practices predicted greater number of egg and chicken production.

**Conclusion:** The use of improved gardening and poultry-raising practices was associated with greater vegetable and poultry production among households. When designing large-scale nutrition-sensitive agriculture programs, providing trainings, but also inputs to the farming households to support their adoption of these improved practices will be critical for ensuring increased and more diverse production.

**Introduction**

Malnutrition remains a challenge in low- and middle-income countries despite several nutrition initiatives and stronger political will among countries than before (Development Initiatives, 2021). A major cause of preventable malnutrition and diet-related non-communicable diseases is a lack of diverse and healthy diets (minimally or un-processed foods that are very high in nutritional contents) (Li et al., 2020). Healthy diets are difficult for some individuals to obtain because of their gender, ethnicity or caste, socio-economic status, and land rights or access (IFPRI, 2020). Lack of availability of resources such as seeds, fertilizers, or markets often present additional obstacles (IFPRI, 2020). In addition, people living in remote areas and urban slums might have limited availability and accessibility of nutrient-rich foods partly due to dysfunctional food supply chains that cannot handle highly perishable food items. These issues of availability and accessibility are aggravated by the limited trainings and inputs people get in such communities (Fidelugwuowo, 2020; Khapayi & Celliers, 2016). Promotion of
improved production-related practices along with provision of inputs and trainings would enable them to produce nutritious foods for their own consumption and sometimes sell to generate additional income (Nordhagen & Klemm, 2018).

Making nutrient-rich foods more affordable, accessible, and available to needy individuals is challenging and requires co-ordination among several sectors. One way to increase availability, accessibility, and affordability of nutrient-rich foods is by promoting homestead gardens (also referred to as kitchen gardens, home gardens, or household gardens) (Marie T. Ruel et al., 2018). The likelihood of consumption of nutrient-rich foods increases if households produce these foods (P. Mulmi & Masters, 2017). Household production among small-holder farmers is crucial for those who cannot afford the cost of nutrient-rich foods in the markets or shops or where markets or shops are inaccessible (Biehl et al., 2016; Hirvonen et al., 2020). Promotion of household production of nutrients-rich vegetables, fruits, and small livestock can improve dietary quality of foods (in Bangladesh, Cambodia and Nepal) (Dulal et al., 2017; Schreinemachers et al., 2020; Schreinemachers et al., 2017; Schreinemachers et al., 2015a; Verbowski et al., 2018), household food security (in Bangladesh and Nepal) (Bushamuka et al., 2005; A. Osei et al., 2017; Talukder et al., 2010), hemoglobin levels (in Bangladesh, Burkina Faso, Cambodia, Nepal, and Philippines) (Kennedy et al., 2017; A. Osei et al., 2017; Talukder et al., 2010), and reduced wasting among children (in Burkina Faso and Zambia) (N. Kumar et al., 2018; D. K. Olney et al., 2015). In addition, household production could provide opportunity for small income generation and women empowerment (Balz et al., 2015; Marie T. Ruel et al., 2018).
Little is known on whether improving production-related practices among people in the communities translates into improved production of nutrients-rich foods (Marie T. Ruel et al., 2018). A study using nutrition-sensitive agriculture project implemented in Ethiopia, Kyrgyzstan, Nepal, Pakistan, and Peru showed an increase in dietary diversity of women through improved production but could not examine the relationship between promoted production-related practices and production (Bernet et al., 2018). A recent study involving randomized controlled trials in Kenya, Tanzania, and Uganda reported intermediate outcomes like training participation, vegetable production techniques, and vegetable production in addition to primary nutrition outcomes like dietary diversity, but did not examine the association between the adoption of production techniques and vegetable production (Depenbusch et al., 2021). A project conducted in four African countries showed the importance of improved poultry-raising practices in egg and chicken production but did not study the relationship between improved practices and poultry production (Nordhagen & Klemm, 2018). Production-related practices along with trainings, inputs, and awareness-creation activities are important to promote improved food production diversity and consumption choices (Bernet et al., 2018; Marie T. Ruel et al., 2018). In addition, Government of Nepal has also identified the need for improved agricultural practices and animal husbandry practices to achieve higher productivity and household food security in the country (Ministry of Agricultural Development, 2014).

The present study contributes to this nutrition-sensitive agriculture literature by studying the association between gardening and poultry-raising practices and diverse vegetables, eggs, and chicken production among households from disadvantaged communities in Nepal. This study helps to understand how the promotion of improved
gardening and poultry-raising practices can improve production of vegetables, egg, and meat in the context where a nutrition-sensitive agriculture intervention has been implemented for several years. To achieve this aim, we used the data collected by *Suaahara-II* among the households located in the districts where homestead food production (HFP) program, a nutrition-sensitive agriculture intervention, has been implemented. We hypothesized that households performing a greater number of improved gardening and poultry-raising practices produced more diverse and greater quantity of vegetables and more chicken and eggs than those performing a smaller number of the ideal agricultural practices.

**Methods**

**Setting**

*Suaahara*, a multi-sectoral program, has been implementing HFP program in 42 out of the 77 districts in Nepal for the improved access to diverse and nutrient-rich foods by women and children (Figure 4.1). Therefore, HFP program has been promoting improved gardening and poultry-raising practices along with training and inputs to increase availability of diverse vegetables, egg, and chicken throughout the year.

Implementation of nutrition-sensitive agriculture interventions like HFP increases the likelihood of promotion of knowledge on methods, practices, food production, consumption, and nutrition in the communities (Bernet et al., 2018). Although these interventions target specific households or individuals to improve knowledge on production-related practices, neighboring people might imitate the practices performed and seek support, resulting in a greater adoption of practices in the communities.
compared to where interventions have not been implemented (Boedecker et al., 2019; Dillon et al., 2020). Some individuals get motivated to adopt the production-related practices while other do not, resulting in a greater variability in adoption of the practices. This variability helps to investigate whether engaging in more improved production-related practices translates to a greater production of quantity and diversity of nutrients-rich foods.

Data collection

The present study utilized data collected from the Suaahara-II monitoring survey in 2017. We used only the monitoring data collected in 2017 because the subsequent rounds of monitoring data collected in 2018 and 2019 lacked detailed information on production-related practices. In addition, the earlier monitoring data collected from 2011 to 2016 was led by a different organization than HKI and the monitoring system was different. A local Nepali firm, New Era, recruited a team of 105 field staff, including 6 quality controllers, 20 supervisors, and 59 enumerators for the data collection. All the field staff were trained to familiarize with the survey objectives and tools. The training included detailed explanations of the survey objectives and design including multi-stage sampling and selection of households and appropriate informed consent and interviewing methods. Each question of every module was discussed, and skip patterns, filtering, and probing techniques were explained. Enumerators were also trained in how to collect data using android phones, using ‘Ona’, an offline data collection application. Face-to-face interviews were done. Once the data was collected and reviewed by the supervisor, the enumerator synced the data to the Ona server. During data collection, field team
supervisors regularly reviewed the data collected by the enumerators prior to syncing the data to the online database.

According to the type of questionnaires (such as household, mothers, child, etc.) response from multiple respondents were recorded in the survey. For this study, information on homestead food production was collected from mothers of children under five years old since the HFP program has been targeting mothers. Information on households and communities was collected from the household heads or mothers (if they were the household heads).

**Sampling**

A multi-stage stratified cluster sampling design was used to collect the data and has been described in detail elsewhere (HKI, 2018). In brief, the first-stage sampling units were districts (n=16). The second-stage sampling units were municipalities (1 urban and 1 rural per district, excluding the district headquarter municipality n=32). The third-stage sampling units were new wards (3 per municipality, n=96). The fourth-stage sampling units were old wards (2 per new ward, n=192) (because of larger size of new wards data collection was logistically challenging, therefore, old wards were selected). The final-stage sampling unit was households with children under 5 years of age (19 per old ward, n=3,648). The first four stages were conducted using probability proportional to size techniques. For the fifth stage, households with a child under 5 years and a mother living in the same house were selected randomly.

In the selected old wards, a listing of households was conducted which contained information about the name of the household head, whether the household has a child...
under 5 years or not, and if yes, the name of the mother of the child. From the list of all households, a list of households having a child under 5 years of age and the child’s mother residing together was prepared and 19 households were randomly selected for inclusion in the survey, by drawing names from a hat. If there was an insufficient number of eligible households in the selected old ward, the same procedures were followed in the adjoining old ward to select the remaining required households.

**Sample size**

_Suaahara-II_ survey collected information on homestead food production among households in addition to information on maternal and child health, dietary practices, empowerment, and other household information. Among the 3,643 households enrolled in the survey, 3,635 households had complete information, therefore, used as the final sample in the analyses.

**Exposure variables**

We had two separate exposure variables:

*Improved gardening practices score*: Gardening practices were determined by assessing the following six activities, a few of which were observed by the interviewers, and some were reported by the respondents: (i) growth of vegetables in a dedicated plot (ii) growth of vegetables within a fenced area; (iii) use of organic manure in the last agricultural season; (iv) use of bio-pesticides (prepared from locally available resources) in the last agricultural season; and (v) use of irrigation. If the respondents reported practice of the activities, a score of 1 was given for each, otherwise 0 was given. Then, we created a total score by summing the individual scores for each practice (range 0 to 5). Higher
score reflected better gardening practices, which could result in improved production of vegetables. Among the ideal and improved gardening practices promoted by the HFP program in the communities of Nepal, these were the ones included in the survey. Adopting only one practice might not suffice for improved and diverse production of vegetables. A household was recommended to perform all of these practices depending upon the type of vegetables grown, which could result in increased availability and productivity of diverse vegetables throughout the year.

*Improved poultry-raising practices score*: Poultry-raising practices were determined by assessing the following seven activities and generating a score of these practices: (i) use of chicken coop for rearing chicken; facilities and conditions of coop: (ii) fresh air and ventilated space; (iii) facility of clean water and pot; (iv) clean or fresh chicken feed and pot; (v) proper security; (vi) deworming chickens; and (vii) vaccinate against New Castle Disease. If the respondents reported practice of the activities, a score of 1 was given for each, otherwise 0 was given. Then, we created a total score by summing the individual scores for each practice (range 0 to 7). A higher score reflected better poultry-raising practices, which could result in improved production of chicken and eggs. In addition to the promotion of gardening practices, improved poultry-raising practices have been promoted in the communities. Among the ideal and improved poultry-rearing practices promoted by the HFP program, these practices were the ones included in the survey. Adopting only one practice might not suffice for increased egg and meat production. Therefore, the HFP program recommends households to adopt all of these practices if they want increased production of eggs and chicken.
Outcome variables

Vegetable production: Vegetable production was assessed by both diversity and quantity of vegetables produced.

Vegetable production diversity: Based on the major nutrients present in the vegetables and adapted from the groupings used in a study of homestead food production program in Bangladesh (Schreinemachers et al., 2016b), we grouped 35 vegetables produced into five types: dark-green leafy vegetables (DGLV), other vitamin A-rich vegetables, beans and pulses, roots and tubers, and other vegetables. This grouping can be related to dietary diversity for children 6 to 23 months of age as guided by World Health Organization (WHO, 2007) and for women as guided by Food and Agriculture Organization (FAO, 2010). Respondents were asked which vegetables they grew in the 12 months. If they reported production of any vegetables from each vegetables group, a score of 1 was given, otherwise 0 was given. For an example, if the mothers reported growth of broadleaf mustard or pumpkin shoot, a score of 1 was given to the vegetable group, “dark-green leafy vegetables”. Then, we summed (range 0 to 5) the individual scores for each vegetable group to create vegetable production diversity score. A list of the vegetables and their groups is provided in the supplementary table 1.

Quantity of vegetable production: Quantity of vegetable production was assessed by measuring kilograms (kg) of vegetables produced by the households in the last 12 months. Respondents were asked how much (in kg) of vegetables they harvested during the last 12 months.
**Poultry production:** Poultry production was assessed by measuring the quantity (in numbers) of chicken and eggs produced by the households separately.

**Egg production:** Respondents were asked how many eggs were produced in the last one month.

**Chicken production:** Respondents were asked how many chickens the households had at the time of survey. Information on three different chicken types: improved (e.g., New Hampshire, Black Australorp); local (e.g., Sakini, Ghanti Khuile); and boilers/layers was obtained. For the analyses, regardless of the types of the chicken raised, the numbers were combined.

**Covariates**

To account for the potential confounding, we identified variables *a priori*, based on published literature and knowledge of the local context and intervention being studied. We grouped the variables by level into individual (maternal), household, and community. Maternal characteristics were age of mothers (in years), education (none, primary, secondary, and higher), major occupation (agriculture and non-agriculture), residency type (whether a mother lived alone, lived with her husband and children, and lived in a nuclear family), mother’s knowledge on agricultural practices, and whether mother was an active member of agriculture/livestock/fisheries producers group in the community (including marketing groups and *Suaahara* HFP group). Mothers’ knowledge on agricultural practices was constructed as a score by summing all the scores based on responses to each question the mothers were asked (such as “What are some potential advantages of having a homestead garden?”, “What are some potential advantages of
producing small animals such as chickens or goats?”). Several options were present for each question, which were not read to the mothers. If they answered the options a score of 1 was given, if they say don’t know or others, a score of 0 was given.

Household-level variables were caste/ethnicity (socially advantaged versus socially disadvantaged), socio-economic status, total land size (measured in hectares), household food insecurity, and anyone in the household received training on improved agriculture and poultry-raising practices. Socially excluded caste groups consisted of Dalits, Muslims, and disadvantaged Janajatis while advantaged caste groups consisted of Brahmins/Chhetri, Gurung/Thakali, Newar, and non-Dalit Terai caste based on the caste/ethnicity defined by the Government of Nepal Health Information and Management System. Socio-economic status was determined using equity quintile (Fry K. et al., 2014). Household food insecurity was measured using the Household Food Insecurity Access Scale developed by Food and Nutrition Technical Assistance project (Coates et al., 2007). Training on improved agricultural practices included: (i) field crop selection or rotation; (ii) improved seeds or crop varieties; (iii) pest management and identification; (iv) soil improvement (fertility and composting); (v) home gardening (other); (vi) water conservation and use for agriculture; (vii) improved post-harvest food storage practices. Training on improved poultry-raising practices included: (i) treating chicken disease, such as Newcastle; and (ii) chicken breeding and husbandry.

Community-level variables were presence of any agriculture/livestock/fisheries group in the community (including marketing groups), and altitude (measured in meters).
Statistical analyses

All the analyses were performed using Stata version 14.2 (StataCorp, Texas). The association between improved gardening practices score and vegetable production diversity was tested using linear mixed-effects regression models (command “mixed” in Stata). The fixed-effects portion of the regression model consisted of improved gardening practices score and the potential confounders identified *a priori* and the random-effects portion consisted of districts.

The association between improved gardening practices score and vegetable production quantity (in kg) was tested by using linear mixed-effects regression models (command “mixed” in Stata). We used a square root transformation to make the distribution of vegetable quantities less skewed and reduce the influence of large positive outliers. The fixed-effects portion of the regression model was the transformed quantity and potential confounders identified *a priori* and the random-effects portion specified districts.

The association between improved poultry-raising practices score and egg and chicken production was tested separately by using left-censored regression models (command “tobit” in Stata). The distribution of the outcome variables, number of egg and chicken production in the past one month, had more than half zeros. The values at zero were treated as censored. The regression model was adjusted for the potential confounders identified *a priori* and clustering at district level (“vce” option in Stata).
Ethical approval

Ethical approval for the study was provided by the Nepal Health Research Council as part of Suaahara’s monitoring system ethical review. Participants were briefed about the purpose of the study. Participation was voluntary and a written consent was obtained before the start of each interview.

Results

About 88% of the households produced vegetables and 57% produced egg or poultry (Table 4.4). About 44% of the respondents had some or completed secondary schooling. Most of the respondents had agriculture as their major occupation (63%) and lived in a joint family (50%). A few respondents were an active member of agriculture/livestock/fisheries producers group in the communities (7%). Most respondents were from a socially disadvantaged caste (61%). A few households had received training on improved agriculture (17%) and poultry-raising practices (5%). About a fifth of the households were present in the communities that had any agriculture/livestock/fisheries group (including marketing groups).

On average, the vegetable production diversity score was 2.8, i.e., households produced about three groups of vegetables in the last year (Table 4.5). The average quantity of all vegetables, dark-leafy green vegetables, and other vitamin A-rich vegetables produced in the last year was 197 kg, 21 kg, and 18 kg, respectively. Mothers having higher education produced a greater diversity and quantity of vegetables than mothers without education. Women living with husbands and own children or in a joint family produced a greater diversity and quantity of vegetables than women living alone.
Socially advantaged households and if anyone in a household received training on improved agriculture or poultry-raising practices had a greater vegetable production diversity and higher quantity of vegetables production. Households from the communities where any agriculture/livestock/fisheries group (including marketing groups) were present had a greater vegetable production diversity and higher quantity of vegetables production.

The average egg and chicken production in the last month were 5 eggs and 7 chickens, respectively (Table 4.5). Mothers having higher education produced more eggs and chickens compared to those mothers without education. Mothers involved in non-agriculture occupation produced more eggs and chicken compared to mothers having agriculture as major occupation. Mothers living with husbands and own children or in a joint family produced more eggs and chickens compared to those mothers living alone. If anyone in a household received training on improved poultry-raising practices, the households produced a greater number of eggs and chicken. Households from the communities where any agriculture or livestock or fisheries group (including marketing groups) were present produced a greater number of eggs and chicken.

In the adjusted regression analyses, for each additional improved gardening practices performed by the mothers, the vegetable production diversity was greater by 0.6 units (Table 4.6). Quantity of all vegetables produced was greater by 2.5 units for each additional improved gardening practices performed. Quantity of DGLV (β=0.6), other vitamin A-rich vegetables (β=0.6), beans and pulses (β=0.5), roots and tubers (β=1.2), and other vegetables (β=1.4) was also greater for each additional improved gardening practices performed. For each additional improved poultry-raising practices performed by
the mothers, the number of eggs and chicken production was greater by about 10 and 31 units respectively.

Discussion

Vegetable production diversity and quantity and egg and chicken production were greater for those households performing a greater number of improved gardening and poultry-raising practices, respectively. Greater quantity of DGLV, other vitamin A-rich vegetables, beans and pulses, roots and tubers, and other vegetables was also associated with improved gardening practices. These findings suggest that production-related practices need to be examined if programs want to improve vegetable and poultry production.

Almost all nutrition-sensitive agricultural interventions attempt to promote improved production practices and methods, but whether the promoted practices improve vegetable or poultry production is less studied (A. Kumar et al., 2020). This study showed that performing more recommended gardening practices improved the quantity and diversity of vegetables production. Farmers might perform a greater number of the recommended practices due to program’s support in improving farmers’ knowledge, group membership, access to credit, and their participation in demonstration trials (A. Kumar et al., 2020; Ochieng et al., 2021). Adopting only one practice, method, or technology might not suffice for improved and diverse production of vegetables. Therefore, along with provision of high quality training and inputs (Ferdous, Datta, Anal, Anwar, & Khan, 2016), interventions recommend that farmers perform all the practices to diversify production and increase quantity of vegetables throughout the year.
Diversity of vegetables production is important because it not only leads to more diverse vegetable consumption (Prajula Mulmi et al., 2017), which are associated with improved health outcomes, but also reduces farmers’ vulnerability to climate change (Reidsma & Ewert, 2008; van Zonneveld, Turmel, & Hellin, 2020). This study used five categories of vegetables to underscore availability of micronutrients from different groups of vegetables. Our study can inform programmers to encourage households for production of selected vegetables to complement the micronutrients available in each other vegetables. For an example, if household members are only growing mustard greens or spinach (excellent source of vitamin A), they can be advised to grow vegetables of other groups such as eggplant (excellent source of vitamin B1 and copper) that complement micronutrients availability from other vegetables (Mateljan, 2020). Studies in Sri Lanka and Uganda measured crop diversity through a simple species count, however, they included other crops like cereals, condiments, etc. in addition to vegetables (Thamilini et al., 2019; Whitney et al., 2018). A home garden pilot intervention in Vietnam also showed improvement in the amount and diversity of vegetables, defined by the individual vegetables count instead of grouping based on micronutrients availability (Ha, Luoh, Sheu, Thuy, & Yang, 2019).

Regarding poultry production, performing a greater number of improved poultry-raising practices was associated with a greater number of egg and chicken production. This finding is corroborated by an evidence from four African countries that showed households with limited uptake of improved poultry-raising practices had low egg productivity, which highlights the importance of performing a greater number of improved poultry-raising practices for increased egg and chicken production (Nordhagen
Generally indigenous chickens have lower growth rate and eggs production due to poor feed and coop management practices in villages (Pym & Alders, 2012). Raising improved breeds of chicken often increases egg and meat production within a relatively short duration, however, these chickens might require more efforts as they tend to be more susceptible to disease than the indigenous ones (Nordhagen & Klemm, 2018; Wong et al., 2017). Therefore, besides improving practices, increasing egg and chicken production requires efforts to overcome challenges such as lack of resources for coop construction, low vaccines supply, and little effort or investment in feed preparation (Nordhagen & Klemm, 2018).

Nutrition-sensitive agriculture interventions often have a goal to improve nutritional outcomes through household production of vegetables, fruits, and small livestock by promoting improved gardening and poultry-raisinig practices along with low-cost but easy to adopt technologies. It is also equally important to consider the number of improved practices to be taught to the farmers. Priority might be needed for farmers, especially from disadvantaged communities, as they might not be able to perform the practices due to several reasons such as less knowledge about the practices, poor motivation, and lack of resources (Nordhagen & Klemm, 2018). Practices learned and performed for a long time help to sustain the benefits of the programs even after the program ends (Baliki et al., 2019).

To our knowledge, this is the first study to examine the association between improved gardening and poultry-raising practices and vegetable, chicken, and egg production in Nepal. The cross-sectional nature of the data allowed us to identify associations, however, could not prove causality between practices and production of
vegetables and poultry. Social desirability bias might have affected the responses, particularly regarding the reliance on recall-based outcomes like assessing growth of vegetables in the past year. This study targeted mothers of children under five years of age from disadvantaged communities, which limits the generalizability to other population and communities. Information on additional ideal gardening practices such as use of insect- or pest-resistant varieties, integrated cultivation systems (mixed cropping, relay cropping), tunnel or plastic house, drip irrigation method, making compost manure, etc. was not collected, which needs to be explored and examined in future studies. Nevertheless, these improved gardening practices that we examined in the study are expected to be taught in a well-designed training program and are important to understand, especially in the context of Nepal where farmers usually adopt traditional gardening methods and practices.

Future research using qualitative methods might be helpful to understand why and how people get motivated to perform the improved production-related practices. Additional research can help to better understand which households are likely to sustain and expand on the inputs they acquire in the community and how to better support that process. Ideally, further research would be helpful to examine whether the HFP component of Suaahara program improved the gardening and poultry-raising practices, which in turn improved the production by collecting information on the direct HFP households. In addition to vegetables and poultry, fruits are excellent sources of micronutrients. Future works on how locally grown fruits can be promoted through home garden interventions might assist achieving improved nutrition outcomes.
Conclusions

Greater number of improved gardening and poultry-raising practices promoted in the communities were associated with a greater quantity and diversity of vegetable production as well as increased number of chicken and egg production. Vegetables and poultry production can be improved and integrated in tandem into nutrition-sensitive agriculture interventions but taking a couple of key points into consideration when designing such interventions may help improve nutrition outcomes.

First, the focus cannot be placed on production alone: there needs to be an emphasis along the chains from technology adoption to changing consumer behaviors including training farmers, ensure they learned the methods well, and are practicing correctly in the gardens. Trainings and methods for improved vegetable and poultry production are usually offered at lower cost and pose less risk, however, they are not easy, and more easily adopted practices for low-resource settings are required (Nordhagen & Klemm, 2018).

Second, supporting vegetable and chicken production by targeting women alone may not be sufficient to increase household production and empower them. Mothers, their husbands, and other family members will likely be involved as they are often involved in agricultural activities (Dhanaraj & Mahambare, 2019; Lowder, Skoet, & Raney, 2016). Supporting activities delivered to the households should go deeper than vegetables, chickens, and eggs to address underlying cultural and gender norms that constrain women’s active participation in homestead food production (Argaw, Phimister,
& Roberts, 2021; Doss, Meinzen-Dick, Quisumbing, & Theis, 2018; Westholm & Ostwald, 2020).

References


Results of three randomized controlled trials. *Food Policy, 104*, 102140. doi: [https://doi.org/10.1016/j.foodpol.2021.102140](https://doi.org/10.1016/j.foodpol.2021.102140)


HKI. (2018). *Suaahara II: Good nutrition program, annual survey year one (2017)*. Retrieved from Lalitpur, Nepal:


Figure 4.1 *Suaahara* Homestead Food Production reach in Nepal
Table 4.5 Sample characteristics of participants from households located in the areas where *Suaahara* HFP program has been implemented in Nepal (N=3,635)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of observations</th>
<th>Percentage/Mean, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable produced</td>
<td>3203</td>
<td>88.1</td>
</tr>
<tr>
<td>Egg produced</td>
<td>1079</td>
<td>29.7</td>
</tr>
<tr>
<td>Chicken produced</td>
<td>2081</td>
<td>57.3</td>
</tr>
<tr>
<td>Mother-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>3635</td>
<td>26.2, 5.5</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>763</td>
<td>21.0</td>
</tr>
<tr>
<td>Some/completed Primary (grades 1-5)</td>
<td>770</td>
<td>21.2</td>
</tr>
<tr>
<td>Some/completed Secondary (grades 6-10)</td>
<td>1613</td>
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</tr>
<tr>
<td>Some/completed higher education (grades &gt;=11)</td>
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</tr>
<tr>
<td>Major occupation</td>
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<td></td>
</tr>
<tr>
<td>Agriculture</td>
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<td>62.6</td>
</tr>
<tr>
<td>Others (Non-agriculture related)</td>
<td>1361</td>
<td>37.4</td>
</tr>
<tr>
<td>Residency type: mother living</td>
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<td></td>
</tr>
<tr>
<td>Alone</td>
<td>707</td>
<td>19.5</td>
</tr>
<tr>
<td>With husband and own children only</td>
<td>1118</td>
<td>30.8</td>
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<tr>
<td>In a joint family</td>
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</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3384</td>
<td>93.1</td>
</tr>
<tr>
<td>Yes</td>
<td>251</td>
<td>6.9</td>
</tr>
<tr>
<td>Household-related</td>
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</tr>
<tr>
<td>Caste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socially advantaged</td>
<td>1431</td>
<td>39.4</td>
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<tr>
<td>Socially disadvantaged</td>
<td>2204</td>
<td>60.6</td>
</tr>
<tr>
<td>Household wealth</td>
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<td></td>
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<tr>
<td>Poorest</td>
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</tr>
<tr>
<td>Poor</td>
<td>1037</td>
<td>28.5</td>
</tr>
<tr>
<td>Middle</td>
<td>964</td>
<td>26.5</td>
</tr>
<tr>
<td>Rich</td>
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<td>Richest</td>
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<td>1.9</td>
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<td>Total land size</td>
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<td>Household food insecurity</td>
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<td>Mild</td>
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<tr>
<td>Moderate</td>
<td>533</td>
<td>14.7</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>Severe</strong></td>
<td>77</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Anyone in the household received training on improved agriculture practices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3015</td>
<td>82.9</td>
</tr>
<tr>
<td>Yes</td>
<td>620</td>
<td>17.1</td>
</tr>
<tr>
<td><strong>Anyone in the household received training on improved poultry raising practices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3462</td>
<td>95.2</td>
</tr>
<tr>
<td>Yes</td>
<td>173</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Community-related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of any agriculture/livestock/fisheries group in the community (including marketing groups)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2916</td>
<td>80.2</td>
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<tr>
<td>Yes</td>
<td>719</td>
<td>19.8</td>
</tr>
<tr>
<td><strong>Altitude (in meter)</strong></td>
<td>3635</td>
<td>909.9, 621.9</td>
</tr>
</tbody>
</table>
Table 4.6 Vegetable and poultry production among households from the communities where *Suaahara* HFP program has been implemented (N=3635)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Vegetable production diversity score, Mean (SD)</th>
<th>Production quantity (in kg), Mean (SD)</th>
<th>Number of egg produced, Mean (SD)</th>
<th>Number of chicken produced, Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, Mean (SD)</td>
<td>2.8 (1.5)</td>
<td>196.6 (492.1)</td>
<td>21.1 (38.2)</td>
<td>18.5 (256.6)</td>
</tr>
<tr>
<td><strong>Mother-related</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.02*</td>
<td>-0.01*</td>
<td>0.07*</td>
<td>-0.01*</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>2.5 (1.5)</td>
<td>169.4 (745.3)</td>
<td>19.3 (37.0)</td>
<td>10.8 (345.7)</td>
</tr>
<tr>
<td>Some/completed Primary (grades 1-5)</td>
<td>2.7 (1.6)</td>
<td>205.1 (445.5)</td>
<td>21.3 (36.1)</td>
<td>14.9 (34.7)</td>
</tr>
<tr>
<td>Some/completed Secondary (grades 6-10)</td>
<td>2.9 (1.5)</td>
<td>259.1 (379.2)</td>
<td>25.5 (38.1)</td>
<td>16.1 (61.8)</td>
</tr>
<tr>
<td>Some/completed higher education (grades &gt;=11)</td>
<td>3.1 (1.5)</td>
<td>375.4 (375.4)</td>
<td>42.9 (42.9)</td>
<td>43.4 (43.4)</td>
</tr>
<tr>
<td>Major occupation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>3.1 (1.3)</td>
<td>230.9 (564.2)</td>
<td>26.3 (42.9)</td>
<td>24.3 (323.1)</td>
</tr>
<tr>
<td>Others (Non-agriculture related)</td>
<td>2.3 (1.7)</td>
<td>139.2 (331.3)</td>
<td>12.4 (26.4)</td>
<td>9.1 (36.4)</td>
</tr>
<tr>
<td>Residency type: mother living</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alone</td>
<td>2.4 (1.6)</td>
<td>190.4 (132.5)</td>
<td>19.4 (28.8)</td>
<td>13.5 (69.1)</td>
</tr>
<tr>
<td>With husband and own children only</td>
<td>2.7 (1.6)</td>
<td>239.2 (456.2)</td>
<td>24.5 (34)</td>
<td>26.2 (84.6)</td>
</tr>
<tr>
<td>In a joint family</td>
<td>3.1 (1.4)</td>
<td>587.6 (587.6)</td>
<td>43.2 (43.2)</td>
<td>357.2 (42.7)</td>
</tr>
<tr>
<td>HFP knowledge score</td>
<td>0.28*</td>
<td>0.09*</td>
<td>0.13*</td>
<td>0.01*</td>
</tr>
</tbody>
</table>
An active member of agriculture/livestock/fisheries producers group in the community (including marketing groups)

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.8 (1.5)</td>
<td>3.4 (1.2)</td>
</tr>
<tr>
<td></td>
<td>(492.1)</td>
<td>(481.5)</td>
</tr>
<tr>
<td></td>
<td>(36.9)</td>
<td>(50.7)</td>
</tr>
<tr>
<td></td>
<td>(265.1)</td>
<td>(79.7)</td>
</tr>
<tr>
<td></td>
<td>(33.0)</td>
<td>(24.4)</td>
</tr>
<tr>
<td></td>
<td>(247.2)</td>
<td>(415.4)</td>
</tr>
<tr>
<td></td>
<td>(161.5)</td>
<td>(153.7)</td>
</tr>
<tr>
<td></td>
<td>(12.2)</td>
<td>(13.7)</td>
</tr>
<tr>
<td></td>
<td>(51.4)</td>
<td>(17.4)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Household-related</th>
</tr>
</thead>
</table>

|        |        |        |        |        |        |        |
|--------|--------|--------|--------|--------|--------|
|        |        |        |        |        |        |
|        | 230.2  | 21.4   | 21.5   | 13.1   | 85.9   | 88.3   |
|        | (419.5)| (35.6) | (89.3) | (28.4) | (322)  | (153.4)|
|        | 174.7  | 20.9   | 16.6   | 10.3   | 59.2   | 67.8   |
|        | (532.9)| (39.8) | (321.7)| (34.8) | (214.6)| (165.5)|
|        | (11.1) | (34.3) |        |        |        |        |

|        |        |        |        |        |        |
|--------|--------|--------|--------|--------|
|        | 208.9  | 21.5   | 21.5   | 12.6   | 74.5   | 78.8   |
|        | (537.4)| (37.7) | (311.0)| (36.0) | (265.6)| (155.7)|
|        | 203.7  | 23.2   | 14.9   | 11.1   | 70.5   | 84.0   |
|        | (456.6)| (45.5) | (48.7) | (30.1) | (283.0)| (219.0)|
|        | 149.0  | 18.5   | 7.3    | 52.9   | 60.7   | 4.6    |
|        | (302.8)| (32.6) | (9.6)  | (29.0) | (14.2) | (241.1)|
|        | 79.1   | 11.4   | 11.0   | 3.5    | 25.9   | 27.2   |

|        | 202.6  | 22.4   | 30.7   | 13.6   | 61.6   | 74.3   |
|        | (265.3)| (33.2) | (8.9)  | (22.7) | (22.5) | (110.8)|
|        | 168.7  | 16.3   | 11.1   | 57.8   | 74.7   | 4.6    |
|        | (250.1)| (42.7) | (89.8) | (28.8) | (17.2) | (31.2)|
|        | 126.8  | 16.1   | 6.4    | 35.1   | 60.4   |        |
|        | (150.1)| (38.4) | (8.8)  | (23.1) | (13.9) | (74.7)|
|        | 202.6  | 22.4   | 30.7   | 13.6   | 61.6   | 74.3   |
|        | (265.3)| (33.2) | (8.9)  | (22.7) | (22.5) | (110.8)|
|        | 168.7  | 16.3   | 11.1   | 57.8   | 74.7   | 4.6    |
|        | (250.1)| (42.7) | (89.8) | (28.8) | (17.2) | (31.2)|
|        | 126.8  | 16.1   | 6.4    | 35.1   | 60.4   |        |

| Household wealth |

|        |        |        |        |        |        |
|--------|--------|--------|--------|--------|
|        |        |        |        |        |
|        | 223.5  | 23.6   | 22.6   | 9.9    | 84.1   | 83.3   |
|        | (406.4)| (40.6) | (104.8)| (21.7) | (277.3)| (164.3)|
|        | 197.0  | 22     | 12.2   | 11.1   | 78.0   | 73.6   |
|        | (455.9)| (34.7) | (48.1) | (26.9) | (369.0)| (169.0)|
|        | 202.6  | 22.4   | 30.7   | 13.6   | 61.6   | 74.3   |
|        | (704.0)| (43)   | (486.4)| (48.9) | (203.1)| (161.4)|
|        | 168.7  | 16.3   | 11.1   | 57.8   | 74.7   | 4.6    |
|        | (225.3)| (33.2) | (8.9)  | (22.7) | (22.5) | (110.8)|
|        | 126.8  | 16.1   | 6.4    | 35.1   | 60.4   |        |
|        | (213.1)| (38.4) | (8.8)  | (23.1) | (13.9) | (74.7)|

<table>
<thead>
<tr>
<th>Total land size</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
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<th>0.10*</th>
<th>0.08*</th>
<th>0.02*</th>
<th>0.08*</th>
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<tbody>
<tr>
<td></td>
<td>0.05*</td>
<td>0.03*</td>
<td>0.04*</td>
<td></td>
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<td></td>
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<tr>
<td>Anyone in the household received training on improved agriculture practices</td>
<td>172.2</td>
<td>19.5</td>
<td>16.4</td>
<td>10.3</td>
<td>56.9</td>
<td>69.2</td>
</tr>
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<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>No</td>
<td>2.7 (1.5)</td>
<td>(465.0)</td>
<td>(35.2)</td>
<td>(278.9)</td>
<td>(31.2)</td>
<td>(169.2)</td>
</tr>
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<td>315.0</td>
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<td>28.9</td>
<td>16.8</td>
<td>132</td>
<td>108.2</td>
</tr>
<tr>
<td>Anyone in the household received training on improved poultry raising practices</td>
<td>192.3</td>
<td>20.6</td>
<td>18.0</td>
<td>11.2</td>
<td>68.3</td>
<td>74.1</td>
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<td>(491.1)</td>
<td>(37.7)</td>
<td>(262.6)</td>
<td>(32.8)</td>
<td>(254.1)</td>
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<td>(66.0)</td>
<td>(25.3)</td>
<td>(394.2)</td>
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</table>

**Community-related**

Presence of any agriculture/livestock/fisheries group in the community (including marketing groups)

<table>
<thead>
<tr>
<th>173.0</th>
<th>19.5</th>
<th>12.8</th>
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<td>(291.6)</td>
<td>(254.0)</td>
<td>(150.5)</td>
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<td>292.0</td>
<td>27.4</td>
<td>41.6</td>
<td>16.8</td>
<td>101.2</td>
<td>105.0</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Altitude (in meter)  

| 0.24* | 0.10* | 0.18* | -0.0001* | 0.04* | 0.11* | 0.07* | 0.08* | -0.01* |

*Pearson’s correlation coefficient
Table 4.7 Association between gardening practices and poultry-raising practices and vegetable and poultry production among households present in the communities where Suahara HFP program has been implemented (N=3635)

<table>
<thead>
<tr>
<th></th>
<th>Bivariate regression β (95% CI)</th>
<th>P-value</th>
<th>Adjusted regression β (95% CI)*</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable production diversity score</td>
<td>0.68 (0.64, 0.72)</td>
<td>&lt;0.001</td>
<td>0.56 (0.52, 0.60)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Production quantity of different vegetable groups (in kg, squared root transformed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All vegetables</td>
<td>3.28 (3.03, 3.53)</td>
<td>&lt;0.001</td>
<td>2.47 (2.22, 2.72)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DGLV</td>
<td>0.77 (0.67, 0.86)</td>
<td>&lt;0.001</td>
<td>0.55 (0.45, 0.65)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other vitamin A-rich vegetables</td>
<td>0.78 (0.66, 0.90)</td>
<td>&lt;0.001</td>
<td>0.56 (0.43, 0.68)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Beans and pulses</td>
<td>0.67 (0.59, 0.75)</td>
<td>&lt;0.001</td>
<td>0.47 (0.39, 0.55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>1.65 (1.44, 1.85)</td>
<td>&lt;0.001</td>
<td>1.23 (1.02, 1.45)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>1.92 (1.76, 2.08)</td>
<td>&lt;0.001</td>
<td>1.42 (1.26, 1.58)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of egg produced*</td>
<td>10.68 (8.36, 13.01)</td>
<td>&lt;0.001</td>
<td>10.03 (7.93, 12.13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of chicken produced*</td>
<td>30.97 (16.77, 45.18)</td>
<td>&lt;0.001</td>
<td>30.57 (16.51, 44.63)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Coefficients from tobit regression

a Adjusted for age of mothers, education, major occupation, residency type, mother’s knowledge on agricultural practices, whether mother was an active member of agriculture/livestock/fisheries producers group in the community (including marketing groups and Suahara HFP group), caste/ethnicity, socio-economic status, total land size, household food insecurity, anyone in the household received training on improved agriculture and poultry-raising practices, presence of any agriculture/livestock/fisheries group in the community (including marketing groups), and altitude
CHAPTER 5
SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

5.1 Summary

The purpose of this study was to gain a deeper insight on the active engagement of VMFs in an HFP program and whether improved production-related practices translate into improved vegetable and poultry production among disadvantaged communities of Nepal. This study used quantitative methods to achieve the goal using two different datasets: (1) Suahara-II VMF profile dataset and (2) Suahara-II data. Studied into two separate research aims, this research helped to understand in improving service provision and quality of nutrition-sensitive programs and production of diverse nutrients-rich foods.

The first aim of this study was to examine demographic, socio-economic, and programmatic determinants of sustained participation and performance of village model farmers in HFP program, a nutrition-sensitive agricultural program that has been implemented in Nepal for more than a decade. This aim addressed research questions at the community level and helped to inform program implementers on which types of individuals to select as VMFs to help sustain agriculture-nutrition investments once the program ends. The active engagement was defined as summed score of the number of four activities performed by the VMFs. Among the VMFs who participated in the study and were interviewed, the mean number of VMF activities was 1.4. Higher levels of education, being a female community health volunteer, being from an upper caste...
household, and having received more additional trainings and inputs were associated with more active participation among VMFs retained in the HFP program. These determinants can be important considerations for successful implementation at a large scale and sustainability of nutrition-sensitive agriculture interventions.

Education enables the community volunteers to effectively community the importance of messages to the households participants (Panday et al., 2019). In addition, education is one of the key reasons for their continued willingness to work as volunteers and has enabled them to take care of themselves as well as other households in their communities (Panday et al., 2019; Panday et al., 2017; Rahman et al., 2010). FCHVs have a remarkable reputation in supporting the health system and making health interventions successful (Kandel & Lamichhane, 2019). FCHVs can apply their experience in community engagement and use this to successfully implement the HFP program (Betron et al., 2020; Panday et al., 2017). FCHVs are favorable conduits to implement interventions because they are from the same communities and people know and trust them (Kandel & Lamichhane, 2019; Lee, 2020). Low social status of community workers hinder their delivery of services to communities (Okuga et al., 2015). People from disadvantaged caste groups face constraints such as lack of land and can be bonded laborers for better-off households reflecting social inequities (Broaddus-Shea et al., 2020; Malik, 2019). Training events empower and increase the VMFs’ knowledge and skills, particularly related to agriculture, whereas the provision of inputs help them to convert this into practice, especially when there are resource constraints. These activities along with the trainings and post training follow-ups might have enhanced VMFs’ confidence level, which enabled them to work more actively.
The second aim of this study was to determine whether the improved gardening and poultry raising practices promoted in the communities could improve production of vegetables and poultry. This aim addressed the research questions at household level. On average, vegetable production diversity score was 3, i.e., the households produced about three groups of vegetables in the last year. The average quantity of all vegetables, dark-leafy green vegetables, and other vitamin A-rich vegetables produced in the last year was 197 kg, 21 kg, and 19 kg, respectively. The average eggs and chicken production were 6 eggs and 8 chicken, respectively. Vegetable production diversity and quantity of all four groups (DGLV, other vitamin A-rich vegetables, beans and pulses, and other vegetables) of vegetable production were greater for those households performing a greater number of improved gardening practices. Egg and chicken production was also greater for the households performing a greater number of poultry-raising practices.

5.2 Strengths and Limitations

A strength of this study is to present empirical evidence of how promotion of improved gardening and poultry-related practices translates into improved household production of vegetable, egg, and chicken among disadvantaged communities in a low- and middle-income country. In addition, scientific rigor used to collect data is an asset. A large sample size used to achieve the first research aim helped to examine the socio-economic and demographic determinants of VMFs remaining actively engaged in a nutrition-sensitive agriculture program multiple years after being selected and trained.

The cross-sectional nature of the data allowed us to identify associations but did not firmly prove causality between covariates and outcomes. Social desirability bias
might have affected the responses, particularly regarding whether the VMFs remained engaged in all the four activities. Reliance on recall-based outcomes like assessing growth of vegetables in the past year might have introduced recall-bias. As we did not have information among those who dropped out of the program, we could not explore the reasons why some VMFs did not continue to work. In addition, being a rapid survey, we collected information only on the four activities performed by the VMFs to measure “active participation”, which, although perhaps not adequate, indicates that by performing these activities a VMF continues to actively serve households in the communities. The second study targeted mothers of children under five years of age from disadvantaged communities, which limits the generalizability to other population and communities. Information on additional ideal gardening practices such as use of insect/pest-resistant varieties, integrated cultivation systems (mixed cropping, relay cropping), tunnel/plastic house, drip irrigation method, making compost manure, etc. was not collected, which needs to be explored and examined in future studies. Nevertheless, these improved gardening practices that were examined in the study are expected to be taught in a well-designed training program and are important to understand, especially in the context of Nepal where farmers usually adopt traditional gardening methods and practices.

5.3 Conclusion, Implications, and Recommendations

Greater number of improved gardening and poultry raising practices promoted in the communities were associated with a greater vegetable production diversity, quantity, and number of chicken and egg production. Higher education, advantaged caste, being a female community health volunteer, and receiving additional trainings and inputs are
characteristics associated with frontline workers’ sustained participation and performance, which, in turn, are necessary for improved service provision and to inform nutrition-sensitive agricultural interventions at scale.

In the context of limited availability, affordability, and accessibility of nutrients-rich foods among low- and middle-income countries, understanding how promotion of improved production-related practices improve production of vegetables and poultry might have important implications for household food security, dietary diversity, and nutritional outcomes. Increased productivity might result in not only greater dietary diversity but also opportunity for additional income generation by selling the surplus produce, egg, or chicken. In addition, through improved production-related practices, agriculture could be environmentally sustainable and contribute to biodiversity. This research might inform policy makers and organizations working with farmers to make targeted efforts to train and motivate farmers to perform improved gardening and poultry-raising practices. Understanding characteristics associated with frontline workers’ sustained participation and performance might inform nutrition-sensitive agricultural interventions at scale for improved service provision.

While this research fosters our understanding of sustained engagement of the frontline workers, production-related practices, and their relationship with the production of vegetables and poultry, much research is still needed to improve nutritional outcomes and meet the governments’ goal in low- and middle-income settings. This research also adds to the Government of Nepal’s need for improved agricultural practices and animal husbandry practices to achieve higher productivity and household food security.

Production of vegetables and poultry can be promoted together in the communities but
taking some key points into consideration when designing nutrition-sensitive agriculture interventions may help improve production and nutrition outcomes.

First, the focus should not be placed on production alone: there needs to be an emphasis along the paths from technology adoption to changing consumer behaviors, including training farmers, ensuring they learned the methods well, and are practicing correctly in the gardens. Well trained farmers underpin sustainability of interventions as they can utilize their knowledge and practice in the gardens even after the interventions conclude. Further, exploring production-related practices among smallholder farmers in disadvantaged communities, where the burden of malnutrition is high, might help policy makers to formulate and implement policies targeting local needs.

Second, qualitative methods might be helpful to understand how determinants including trainings, inputs, education, and caste/ethnicity help to sustain the participation and performance of farmers in nutrition-sensitive agriculture interventions. Trainings and methods for improved vegetable and poultry production are usually offered at lower cost and pose less risk, however, they are not easy, and more easily adopted practices for low-resource settings are required (Nordhagen & Klemm, 2018). How and over what period of time the frontline workers use their knowledge and skills honed by participating in nutrition-sensitive agricultural interventions might help understand sustainability of such interventions (Baliki et al., 2019; Nordhagen et al., 2019). Additional work is necessary to better understand which households are likely to sustain and expand on the inputs they acquire in the community and how the implementers can better support that process.
Finally, we need to understand how to sustain frontline workers and to promote production-related practices among poor and disadvantaged population as they function differently than the average population (Banerjee & Duflo, 2012). Encouraging improved production-related practices among farmers, especially women, from poor and disadvantaged communities might not only enable production of vegetables and poultry throughout the year but also support and empower women in low- and middle-income settings. Motivating women in low- and middle-income countries including Nepal is crucial because women provide most of the labor force for agricultural production in addition to their traditional household chores (FAO, 2019; Food and Agriculture Organization, 2011). Supporting vegetable, egg, and chicken production by targeting women alone, however, may not be sufficient to increase household production and empower them. Interventions will likely need to involve mothers, their husbands, and other family members as they are often involved in agricultural activities (Dhanaraj & Mahambare, 2019; Lowder et al., 2016). Supporting activities delivered to the households should go deeper than vegetables, chickens, and eggs to address underlying cultural and gender norms and caste issues that constrain women's active participation in homestead food production (Argaw et al., 2021; Doss et al., 2018; Westholm & Ostwald, 2020).
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