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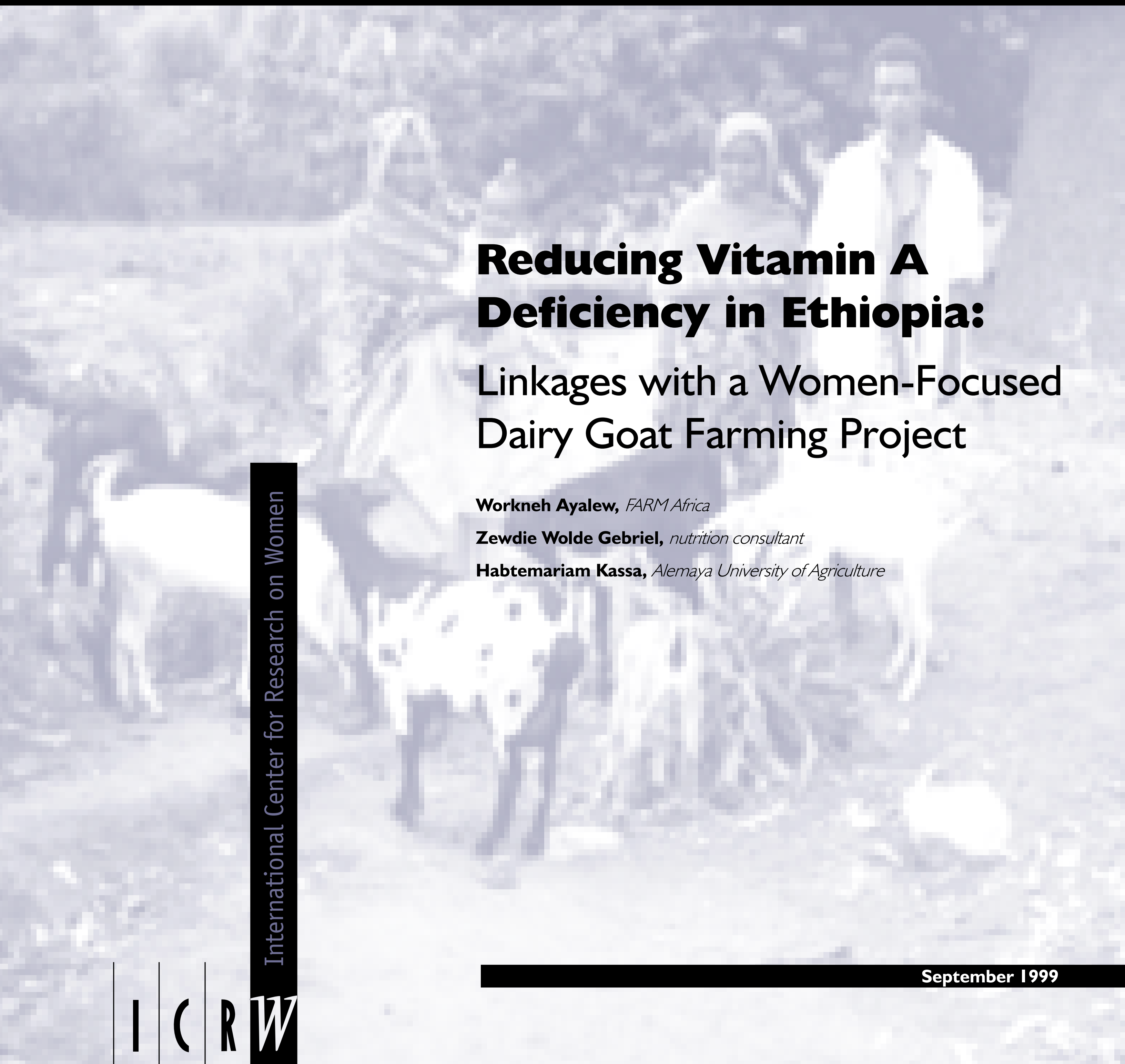

Reducing Vitamin A Deficiency in Ethiopia:

Linkages with a Women-Focused Dairy Goat Farming Project

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Introduction

Many at-risk populations in developing countries are deficient in iodine, iron, and vitamin A, making them more vulnerable to illness, fatigue, blindness, and memory loss and increasing the possibility of mental retardation among their children. Enhancing these micronutrients can result in improved well-being and physical development. Infants and pre-school children would have greater chances of survival, better health, and increased intellectual capacity. Women could have improved pregnancy outcomes and increased productivity. Supplementation, food fortification, dietary diversification, nutrition education, and food production are strategies that have been developed to reduce these micronutrient deficiencies and have, for the most part, demonstrated positive, though uneven, results. For instance, recent data indicate progress worldwide in combating vitamin A deficiency; however, subclinical deficiencies of this micronutrient remain uncontrolled. Further, iron deficiency anemia continues to affect as many as 43 percent of women and 34 percent of men globally (ACC/SCN 1997), with widely divergent regional differences in rates. In order to virtually eliminate vitamin A deficiency by the Year 2000, and to reduce iron deficiency anemia among women of reproductive age and young children by one-third of 1990 levels, continued efforts must be made to strengthen and enhance intervention strategies.

The International Center for Research on Women (ICRW), a nonprofit policy research institution that promotes economic and social development with women's full participation, attempted to address these issues through a two-year intervention research program implemented in five countries. Working with partners in Ethiopia, Kenya, Peru, Tanzania, and Thailand, ICRW undertook a series of studies to explore ways to strengthen women's contributions to reducing iron and vitamin A, and to a lesser extent iodine, deficiencies by combining women's productive and reproductive activities. The idea was to tap into women's roles as income earners and food producers on the one hand, and as food processors and care givers on the other. Community members, particularly women, drew on their knowledge and experiences to develop and implement solutions to micronutrient deficiency problems in their communities. The studies were supported by the Opportunities for Micronutrient Interventions (OMNI) Research Project, managed by the International Life Sciences Institute (ILSI) and funded by the United States Agency for International Development (USAID).

The studies were conducted in Ethiopia, Kenya, Tanzania, Peru, and Thailand. In **Kenya**, an intervention research project introduced new varieties of sweet potatoes rich in beta carotene to women farmers. The Kenya Agriculture Research Institute provided planting materials and agricultural extension agents trained women in methods for growing and harvesting sweet potatoes, post-harvest processing, and preparation techniques. In addition, health and nutrition education sessions were conducted to heighten awareness of the contribution vitamin A makes to children's health and development, and to encourage consumption of food products using the new sweet potato varieties. The intention was to create supply and demand for the new food products, both in the household and for market sales.

The **Peru** study was designed to explore the use of participatory methodologies to engage women members of community kitchens in peri-urban Lima in the design, implementation, and evaluation of a trial intervention to reduce iron deficiency among women of reproductive age. The intervention trial focused on improving the quality of service in terms of nutritional content of meals and management practices, such as instituting quality assurance checks on meal preparation and kitchen hygiene, and stimulating demand for these innovations through health and nutrition education.

In **Tanzania**, the focus was on the adoption of new home-based solar food dryers to increase year-round availability of vitamin A-rich foods. The dryers were adaptations of earlier models and were designed to be more cost effective and accessible. Community members provided all the materials for constructing their household dryers. The research project trained local artisans to construct and maintain the dryers, and provided a short-term incentive to artisans to conduct home visits. Nutrition and health education and business training for marketing surplus production of solar dried vitamin A-rich foods and food products complemented this technology intervention.

In **Thailand,** the research team built on experiences from an earlier social marketing intervention that increased production and consumption of the ivy gourd plant and other foods rich in vitamin A. Women leaders in their communities were trained in problem-solving methods and community mobilization techniques. The women then organized their communities to develop and implement plans of action to improve iodine, iron, and vitamin A status. The project provided small seed grants to support the costs for implementing some of the community-based actions, including food production, local preparation and sale of iodized salt, and health and nutrition education.

This report summarizes findings from **Ethiopia.** The trial intervention implemented there aimed to improve vitamin A status among women and young children. It built on the achievements of a previous dairy goat project designed to improve household income and well-being. The current study expanded the technology package from that project to include interventions specifically aimed at eliminating constraints on vitamin A intake, including health and nutrition education, skills training in gardening and food preparation, and distribution of vegetable seeds. A post-intervention study compared participants and non-participants in the trial intervention with regard to food intake and clinical signs of vitamin A deficiency.

Background

Because 85 percent of Ethiopia's economically active population lives in rural areas, agriculture is the mainstay of the country's economy (FAO 1996). This sector provided 57 percent of Ethiopia's gross domestic product in 1995 (IBRD 1995). Strengthening agricultural production and rural livelihoods is key to improving food security and nutritional well-being in Ethiopian households.

The intervention research project took place in Kombolcha and Gursum, two districts in the Eastern Hararghe Zone (Oromia Region) in eastern Ethiopia, which borders the Somali and Afar Regions close to Djibouti. The area is representative of the densely populated highlands of Ethiopia, the inhabitants of which continually struggle with food insecurity. Small land holdings, low crop productivity, declining soil fertility, and erratic rainfall characterize the highlands, which account for 37 percent of Ethiopia's land area and hold 45 percent of the population. Household farming systems in the highlands include rainfed agriculture and livestock raising, strategies that aim to reduce risks and achieve food security. In fact, 58 percent of cattle, 66 percent of sheep, and 36 percent of goats in Ethiopia are raised in these highland areas (Jahnke 1982).

Gursum is approximately three and a half times the size of Kombolcha, has a slightly lower population density, and larger cultivated landholdings (sometimes twice as large) (Ayalew et al. 1998). While sorghum, maize, and wheat are the major food crops in both districts, Gursum produces more coffee and *chat* for internal and external markets.[1]

Nearly 61 percent of households in the study area were reported to have home gardens, with an additional 10 percent using inter-cropping techniques to produce vegetables in family fields. Vegetables are relatively important to maintaining food security, with most (63 percent) consumed at home and the rest sold in local or regional markets. The most commonly grown vegetables were potato (30 percent of households), cabbage (28 percent), tomato (16 percent), and pumpkin (10 percent), followed by kale, beet root, green pepper, and carrot. The production of fruit is comparatively low, with only 40 percent of households owning any fruit trees. The most commonly cultivated fruits were guava (31 percent of households), *gishta* (28 percent), papaya (22 percent), and mango (13 percent) (Ayalew 1998).

Women's Lives

Women guarantee household nutrition through both their economic activities (including agricultural production) and care-giving skills. In Ethiopia, women spend as many as five hours every day collecting water and fuelwood and traveling to/from markets and grain mills (World Bank 1998).[2] Qualitative household-level data collected by the current study suggest that assets, including livestock, are generally owned jointly by Ethiopian husbands and wives. Decisions regarding the sale of livestock or harvests and the use of revenue are typically made by the male head of household, while women tend to decide about the daily purchases of food items[3] (Ayalew et al. 1998).

Furthermore, custom tends to restrict women's access to productive resources. For example, women make up only 12 percent of the members of rural Peasant Associations (PAs)—through which households are able to access the resources necessary for agricultural production—because the one membership that is usually purchased is

[1] *Chat* is an indigenous plant, the leaf of which is chewed as a stimulant.

[2] This estimate does not take into account the additional time spent selling agricultural produce, food products, and other goods, a major income-earning activity for Ethiopian women.

[3] These items include cooking oil, spices, and other condiments, maize, sorghum, milk, and sweet potatoes; the purchase of meat, some legumes, and *chat* tends to be under the control of men or decided jointly (Ayalew et al. 1998).

most often for a male. In addition, 96 percent of agricultural extension agents are male, limiting women's access to the information and training that could enhance their productivity (World Bank 1998). Such constraints strongly affect the 20 percent of households in Gursum and Kombolcha that are headed by women, primarily widows (Ayele 1998).

Key indications of women's compromised status in Ethiopia include uneven access to education. While only 36 percent of all Ethiopian children enroll in primary school (one of the lowest rates in Sub-Saharan Africa), the enrollment of girls is even worse at 28 percent, compared to 44 percent for boys (World Bank 1998). In the two study areas, 90 percent of women (versus 59 percent of men) were illiterate, according to 1996 data (Ayalew et al. 1998).

Access to health care is also restricted, as reflected in a nationwide contraceptive prevalence rate of only 2 percent.[4] In the study area, slightly fewer than half of women had received two doses of tetanus toxoid in their last pregnancy and only one-third had ever visited an antenatal clinic. The long distance to health sites in rural areas has been cited as a severe constraint (particularly in Kombolcha), as well as inability to pay, poor transportation systems, and low quality of care (Ayalew et al. 1998).

Food Consumption

According to a farming systems study conducted in Kombolcha, 60 percent of rural households had consumed two kilograms of meat per person the previous year, while the remaining 40 percent had not consumed any (Kassa 1986). The study also found that the typical diet was composed of sorghum pancake (*injera*), eaten with sauce made of fenugreek, flax, and salt, supplemented by maize, and sweet potatoes; consumption of meat and milk was typically restricted to holidays or ritual occasions. Green leafy vegetables and fruits were rarely eaten due to food preferences, limited physical and economic access, and seasonal availability (Ayalew et al. 1998). Although Gursum has similar food consumption patterns, its higher population density and more recurrent droughts translates into less overall food security than experienced in Kombolcha.

Using the Helen Keller International (HKI) food frequency method, data collected from 15 villages in the study area just prior to the trial intervention indicated extremely low consumption of foods rich in vitamin A.[5] On average, animal sources of vitamin A were consumed less than once a week (0.7 days) and the weighted total of animal and vegetable sources was only 1.6 days/week, well below the cut-off of 6 used to determine whether or not a community is at risk of vitamin A deficiency (Ayalew et al. 1998).

Breastmilk is the best source of vitamin A for infants, presuming that their mothers are well-nourished (Stoltzfus 1994). In the study area, the mean age of breastfeeding is 18.6 months, with half of mothers breastfeeding their children through the second year and 10 percent stopping after six months. Nearly all mothers give colostrum as well as supplements (mostly water or water mixed with salt, sugar, butter, or other food) to their newborns.

Eighty-five percent of children receive supplemental feeding by the age of six months, including *injera*, porridge, or mashed potato. Milk from animals is a key source of nutrients—including preformed vitamin A in livestock-producing areas such as Kombolcha and Gursum—and is typically prepared in the form of *hoja*, a mixture of boiled coffee leaves with milk and water. This drink is consumed by adults (most often men) during *chat* chewing sessions (Ayele 1998). Young children rarely consume milk.

[4] This rate largely reflects a scarcity of family planning services, which are provided at only one-quarter of health centers in Ethiopia (World Bank 1998).

[5] This method—developed by Helen Keller International in 1993—yields scores that reflect the number of days per week that children under five years of age consuming animal and plant foods rich in vitamin A. According to HKI guidelines, communities with an animal source index of < 4 days/week or a mean weighted total food frequency index of < 6 days/week are considered at risk of vitamin A deficiency.

Nutritional Status and Vitamin A Deficiency

Anthropometric measurements are useful indicators of malnutrition. National data collected in 1992 by the Central Statistical Authority found that alarmingly high numbers of Ethiopian children under five years of age were underweight (47 percent) or suffered from stunting (64 percent) or wasting (8 percent) (CSA 1992). In the current study area, 36 percent of children under five years old were underweight, 46 percent were stunted, and 14 percent were wasted (Ayalew et al. 1998).

Vitamin A deficiency is an acknowledged phenomenon in both Kombolcha and Gursum. Data collected just preceding the current study found that nearly 5 percent of children under five were reported by their mothers to have "night blindness" (an early indicator of the deficiency),[6] yet fewer than 10 percent of these children received vitamin A supplements (Ayalew et al. 1998).

Night blindness among pregnant women is a reliable predictor of households suffering from food insecurity and overall nutritional vulnerability (World Vision 1998). It is therefore relevant to note that 15 percent of women surveyed in 1996 in the study area said that they suffered from the condition during their last pregnancy. In addition, a national nutrition survey by the Ethiopian Nutrition Institute found that 10 percent of pregnant women had serum retinol levels under the recommended value of 10 micrograms per 100 milliliters (Wolde Gebriel et al. 1991).

A national study conducted by the former Ethiopian Nutrition Institute found Bitot's spots and corneal xerosis (both observable, clinical signs of vitamin A deficiency) in 1 percent and 0.1 percent, respectively, of preschool children (ENI 1980).[7] A recent study in Eastern Hararghe suggests there have been no improvements since that earlier study; more than 7 percent of children still have Bitot's spots and 0.4 percent show signs of corneal xerosis (Hailegiorgis et al. 1996).

In recognition of these problems, the new health policy of the Ethiopian government pays special attention to micronutrient deficiencies and encourages and supports efforts to monitor and control these problems. As a result, vitamin A capsules are being distributed in some areas.

Other activities include sensitization of health workers to the scale and severity of micronutrient deficiencies, as well as appropriate treatment protocols. Public awareness of the importance of horticultural development to reducing health and nutrition problems is promoted through the mass media and in schools, while health education sessions for women at health centers also focus on micronutrient deficiencies.

The Dairy Goat Development Project

Beginning in 1988, the Dairy Goat Development Project (DGDP) was implemented by FARM Africa, a nongovernmental organization based in the United Kingdom, in partnership with the Alemaya University of Agriculture (AUA) and the Ministry of Agriculture. The project targeted the poorest of households (i.e., those without livestock) and aimed to increase women's access to productive assets, in particular dairy goats. It was assumed that the ownership of goats would help generate household income, in turn facilitating the purchase and consumption of milk, meat, and other foods, as well as the use of health services. Ultimately, household well-being would improve.

Operating in six sites in Gursum, Kombolcha, and Deder districts and ultimately involving 500 families, the project followed a step-by-step plan of implementation. Women first organized themselves into small self-help, credit, and savings groups. They learned how to grow better forage and to provide appropriate shelter and veterinary care for goats.

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[6] This level is much higher than the 1 percent cut-off value suggested by the International Vitamin A Consultative Group (Underwood and Olson 1993).

[7] These are much higher than the cut-off value of 0.5 percent for Bitot's spots and 0.01 percent for corneal xerosis suggested by the International Vitamin A Consultative Group (Underwood and Olson 1993).

Having demonstrated the ability to do this, most women received local goats. Those participants who both demonstrated the ability to care for goats and who repaid (in-kind) the credit given for the animals received crossbred goats, which have higher milk yields but demand more care. The project also provided in-service training to agricultural extension staff working directly with the women.

A socioeconomic impact assessment of the DGDP found that the project increased the per capita income of goat-owning households by about 18 percent, increased the use of goat milk for home consumption and sale, and encouraged savings and credit activities among participating women (Kassa et al. 1995). It also became clear that crossbred goat owners benefited more than local goat owners.

However, it appeared that the technology package did not contribute to improvements in health and nutritional status. This was not surprising because nutritional status is dependent not only on income, but also on food availability and health-promoting and care-giving practices, factors that the DGDP did not specifically address.

Members of a participating household milk and tend goats near home-grown fodder

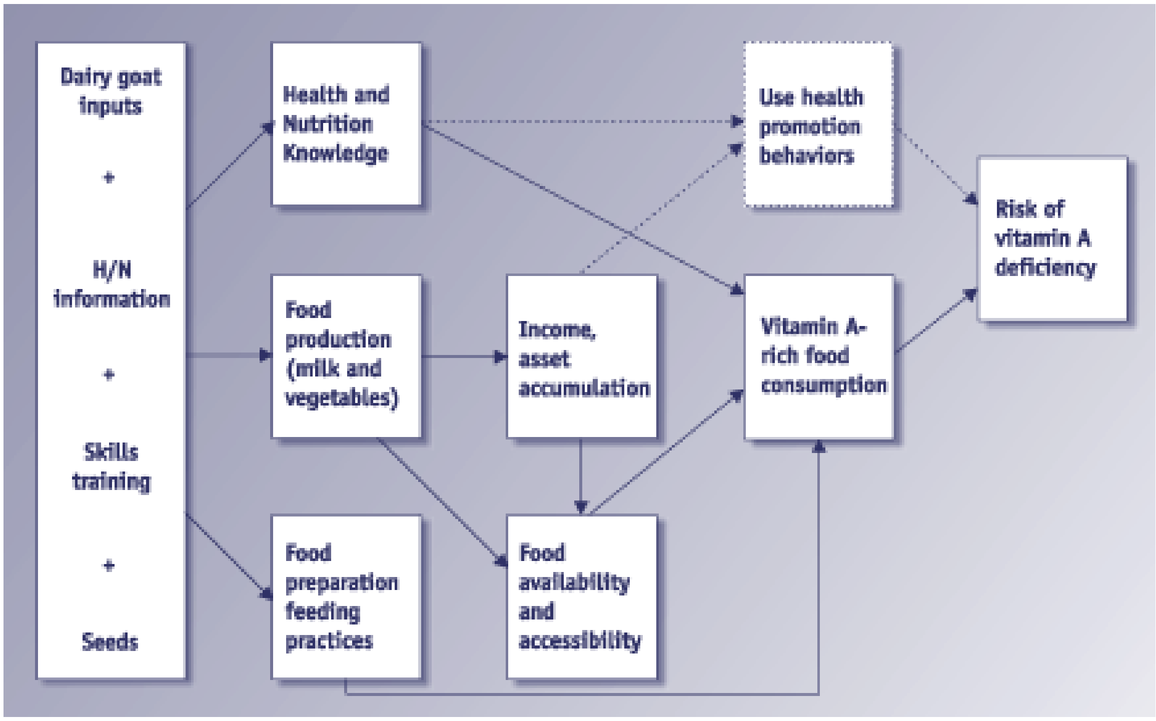
Conceptual Framework and Study Design

Undertaken in 1995-1998 by FARM Africa and the AUA, in partnership with the Ministry of Agriculture extension agents and Ministry of Education staff at local primary schools, the current study addressed some of the limitations of the DGDP. The study hypothesized that inputs provided by the dairy goat project alone would not be sufficient to reduce the risk of vitamin A deficiency, as measured by clinical signs. The study was therefore designed to identify factors on the household level that constrained members' abilities to improve vitamin A intake and reduce vitamin A deficiency. It also aimed to address these constraints and to assess the intervention's effect on reducing vitamin A deficiency among both participants and non-participants.

The conceptual framework for the study is illustrated in figure 1. It suggests that the risk of vitamin A deficiency can be reduced through improved food consumption and feeding practices. The dairy goat inputs (i.e., dairy goats provided on credit, training in goat management and care, and access to veterinary services) would be complemented by other inputs. These were to include health and nutrition information, skills training in production of vitamin A-rich foods and feeding practices, and seeds with which to grow vitamin A-rich vegetables. Together, both sets of inputs would permit household members to improve their knowledge and understanding of the links between food consumption and health, increase food production, and improve methods of preparing and feeding meals to young children. Finally, increased agricultural production would yield higher income and asset accumulation and improve the accessibility and availability of food.

To measure the effects of the intervention, a sample was drawn from three PAs in Gursum (out

Figure 1. Conceptual framework: Linking productive inputs to risk of vitamin A deficiency*



**Data collection and analysis focused on the relationships indicated by solid lines. Dotted lines indicate relationships that were presumed but not tested.*

Table 1. Time frame for project implementation

Date	Activity
December 1995	Pre-intervention instrument development, training of enumerators
February-March 1996	Household survey, data collection and analysis
April-May 1996	Formative data instrument development (pretest and revision); training of enumerators
June-July 1996	Formative data collection and analysis
September-November 1996	Design of trial interventions
December 1996-August 1997	Implementation of trial interventions
January-March 1998	Evaluative data collection
April 1998	Analysis of evaluative data and preparation of research report

of a total of 36 that existed) and one in Kombolcha (out of 14). This selection was based on level of participation in the DGDP. Within each PA, households were identified according to goat ownership, i.e., those with crossbred goats and those with local goats. A control group of households with no goats was also established. Purposive samples were then drawn from the three types of households, as illustrated in table 2.

Methods

Both qualitative and quantitative data were collected in order to design and evaluate the trial intervention. This information included: sociodemographic variables; household decisionmaking patterns; dietary and health beliefs, knowledge, and practices; health service utilization; household expenditures and revenue; food intake;[8] and height and weight measurements of children under five. The baseline was replicated in the evaluation phase, which also included clinical assessments of vitamin A deficiency among children under five and women.[9] Qualitative data were collected to determine community members' satisfaction with the intervention and its perceived benefits.

To evaluate the effects of the intervention, Chi square analysis and analysis of variance (ANOVA) were used to test the statistical significance of differences between participants and non-participants. The data were analyzed for varia-

Table 2. Sample size at post-intervention

	Kombolcha	Gursum	Total sample size
Post-intervention	122	242	364
Crossbred goat owners	32	56	88
Local goat owners	13	83	96
No goats	77	103	180

[8] Food intake was measured using the HKI food frequency method (see footnote 5 for explanation).

[9] These included night blindness and Bitot's spots. A biochemical assessment of vitamin A status was not undertaken due to resource constraints.

tions by district, goat ownership, goat breeds, and participation in the trial intervention activities. (See Appendix A for more detail.)

Study Limitations

Several factors limited the options available for analyzing data. As a result, the only meaningful comparisons that could be made involved post-intervention data on "participants" and "non-participants" in the intervention. First, only 68 percent of participants (247) in the baseline survey were available for reassessment following the intervention and the index children were not necessarily the same in the baseline and the post-intervention samples. Second, only 33 percent of these post-intervention households had maintained the same pattern of goat ownership over the two-year period, that is, they did not acquire new or lose previous goats.

Finally, an ethical dilemma arose regarding the limitation of access to intervention activities within a particular village. This gave rise to the use of a new control group of households without goats, about half of which were known to have attended at least one intervention session. However, due to self-selection, these households could not be screened regarding poverty status, and the standard that the DGDP had initially set (i.e., to involve only the poorest of the poor) could therefore not be guaranteed.

Local data collector interviews members of a participating household

Intervention

Data collected to design the intervention suggested a generally poor level of awareness among study members on the link between food consumption and children's health. In addition, they had limited knowledge of health promoting practices, including environmental sanitation and the nutritional value of locally-available foods (particularly those rich in vitamin A) and how to produce and use these foods. Further, as mentioned earlier, health care utilization rates were low due to the long distance to health posts and the high cost of transportation and services.

These data were discussed at an intervention planning workshop held at the AUA in October 1996. Participants included representatives from the Ministries of Agriculture, Education, and Health, UNICEF, FARM Africa, AUA staff and students, and the International Center for Research on Women (ICRW). Discussions focused on selecting a set of feasible intervention activities, including vitamin A supplementation, nutrition education, food production, and plant breeding.

Despite elevated levels of vitamin A deficiency, it was decided that vitamin A capsule distribution would not be pursued, primarily because of the absence of a community-based health care structure and communities' lack of access to fixed health care sites. Zonal Health officials also noted that the supply of capsules was unreliable even at the fixed sites that did exist.

Further, using agriculture extension agents to distribute capsules went beyond the Ministry of Agriculture's mandate and (even if the agents took on the distribution task) workshop participants were concerned about potential over-dosage of pregnant and lactating women. Instead, it was recommended that the intervention should focus on improving women's and other community members' knowledge and skills regarding the production and consumption of vitamin A-rich foods and the use of health-promoting practices and services.

Activities principally took place at the community level, particularly through women's groups (many of which had been organized through the DGDP), with some support given to primary schools. The nine-month intervention phase began with two seminars conducted in each of the study districts. These aimed to foster awareness among leaders of women's groups of the causes and prevention of vitamin A deficiency.

Sixty women from Gursum and 46 from Kombolcha attended the seminars, as well as the media and representatives from the Ministries of Agriculture, Education, and Health. Trainers included representatives of the Zonal Administrative Council, the Head of Women's Affairs, district development agents from the Ministry of Agriculture, family planning agents, and field nutritionists. In addition, eight enumerators were trained to provide technical support to the communities and schools. Two agricultural extension agents, one health worker, and delegates from the Ministry of Education, District Administration, and the City Council also participated in the training. Two field nutritionists supervised the fieldwork.

The senior nutrition consultant worked with the field nutritionists to develop a set of health and nutrition messages for use at community education sessions and for broadcast on radio and television. Messages focused on problems associated with low vitamin A intake (e.g., blindness, morbidity, and mortality) and symptoms of vitamin A deficiency. Information on how to reduce these problems was also provided, including breastfeeding, consumption of vitamin A-rich foods (principally fruits, vegetables, and milk), immunizations, taking vitamin A capsules, and improving personal and environmental hygiene, household organization, and child care. The radio program was broadcast four times and three television documentaries were produced and broadcasted.

At the community level, five education sessions were held for the public in each of the 12 communities. Educational information using the key messages described above was presented and hands-on demonstrations were given on fruit and vegetable production techniques, food processing, and meal preparation using locally-available foods. Vegetable seeds (provided by FARM Africa) were distributed to all participants. Following the initial sessions, both the agricultural extension agents and field nutritionists met informally with community members to respond to their questions, clarify misinformation, and assist with any difficulties in preparing meals or producing vegetables in new or expanded gardens. No home visits were made.

At the school level, the health and nutrition messages were shared with teachers (who were encouraged to include them in their lessons) at three locations in Kombolcha and seven in Gursum. The project provided seeds and some technical support in planting, caring for, and harvesting the food crops already promoted by the Ministry of Education through school garden clubs. Produce was either consumed at school or taken home by club members.

Local data collectors embark to gather information on family health and nutrition

Project Results

This section reports the analysis of data designed to assess the effects of the community-based intervention.[10] Both results of a descriptive nature and results emanating from the multivariate analyses are reported.

Descriptive Results

Post-intervention data were collected from 364 households, 320 of which provided a complete set of information. Two-thirds, or 214, were classified as "participants" because at least one family member had participated in the trial intervention. The remaining 106 households were classified as "non-participants." Fifty-three percent of the participants said they had attended all intervention sessions, 32 percent had attended most, and 13 percent had attended only a few. Half of those who did not participate said they had not heard about the sessions, while another 30 percent said they had no time to attend. No difference in attendance rates was observed between the two districts.

Household characteristics. One-third of the sample households were from Kombolcha and the rest from Gursum, together representing just over 1,000 people. Average household size was 5.59 persons and the ratio of males to females was 1:0.98. (Households in Gursum were significantly larger than those in Kombolcha: 5.82 versus 5.14 persons, $p < 0.002$). The population was quite young, with an average age of 23 years (excluding children under five). Women headed fewer than 2 percent of the households.

Perhaps because of their larger household size, Gursum residents cultivated 6 percent more land than did the Kombolcha households. They also had more livestock holdings, as measured by tropical livestock units[11] (1.741 compared to 1.283) and a greater proportion of school-aged children attending school (42 percent versus 18 percent). Revenues from agricultural production also tended to be higher in Gursum, primarily because of the prevalence of cash crops such as coffee and *chat*. Participant households had on average higher revenues than non-participants (see table 3). However, households in both districts tended to have higher expenditures (32.25 birr/week) than revenues (27.54 birr per

Table 3. Characteristics of participants and non-participants

Indicator	Participants	Non-participants
Household revenue	30.57 birr/week	20.16 birr/week[a]
Wasted (children<5)	20%	16%
Underweight (children<5)	40%	43%
Stunted (children<5)	43%	45%
Know that fruits & vegetables can prevent night blindness	60%	20%[a]
Feed 1-3 year old child at least four times/day	61%	52%[b]
Have a home garden	38%	15%[a]

[a] $p<0.01$

[b] $p<0.05$

[10] Because the activities in primary schools were secondary to the community-based interventions, they are not reported here.

[11] Tropical Livestock Units: 1 cow = 0.7 Unit; 1 goat = 0.1 Unit; 1 sheep = 0.1 Unit (Jahnke 1982).

week).[12] Malnutrition rates among young children were alarmingly high and similar to previously reported rates in the region; they did not vary significantly according to participation in the intervention or gender of the index child (see table 3).

Strengthening nutritional knowledge and practices. The education component of the intervention aimed to increase participants' knowledge of the causes, treatment, and prevention of vitamin A deficiency, as well as of appropriate feeding practices. Data suggested that participants tended to be more knowledgeable than non-participants. For example, about 60 percent of participant household members knew that night blindness could be prevented through consumption of vegetables and fruits, compared to only 20 percent of non-participants. Similarly, significantly more participants than non-participants reported that consumption of fruits and vegetables was beneficial ($p < 0.001$). In terms of feeding practices, a larger proportion of participants than non-participants (61 versus 52 percent) felt that children 1 to 3 years of age should eat at least four times a day (see table 3).

Focus group participants said that the intervention taught them how to improve the health and nutrition of their children without resorting to expensive traditional remedies (e.g., slaughtering a goat) and that, in general, they had the means to take action independent of medical services. They also said they knew how to recognize, prevent, and treat nutritional problems.

Expanding food production. The intervention promoted the production of vitamin A-rich fruits and vegetables. Although fewer than half of the sample members had a vegetable garden, all of the gardens that were started during the intervention period were owned by participating households (see table 3). In addition, households in Gursum were twice as likely to have a vegetable garden than those in Kombolcha (36 percent versus 18 percent).

Three-quarters of those people with vegetable gardens said they initiated or expanded them to improve food availability, while the remaining households cited income generation as their motivation. The difference between the two districts was particularly striking in this regard, with 76 percent of households in Kombolcha but only 9 percent in Gursum stating that they used backyard gardens for income.[13] Focus group participants noted that a lack of seeds and water shortages were major constraints to vegetable production and that without the intervention training in production techniques, they would not have been able to increase their production of vitamin A-rich foods.

In contrast to vegetables, the main reason cited for having fruit trees was to generate income. Only 29 percent of study households (most in Gursum) reported having fruit trees. During the two-year project period, 66 percent of the study households growing fruit trees increased their number of trees, a pattern that was more prevalent among households that attended the education sessions.[14] However, because of a rapidly expanding market, more households shifted production to *chat* (an easily cultivated plant), suggesting that fruit production may decline in the future. In addition, the demand for fruit may be limited due to the fact that the harvest season (April-July) coincides with the time when food supplies are limited. Households may therefore use their scarce cash to meet different needs than buying fruit. This suggests that it may be more reasonable to promote the production of other vitamin A-rich foods.

[12] All monetary conversions in this report are 7.5 Birr = $1US (1997). This difference could be a result of under-reporting income (e.g., from remittances or off-farm earnings) or not counting the financial value of trade with family and friends or through food-for-work programs. However, it is not unusual for such a negative balance to occur in poor households, which might be borrowing money to cover consumption needs

[13] This may reflect the higher relative wealth in Gursum than in Kombolcha, as suggested by variations in land and livestock holdings and levels of cash cropping.

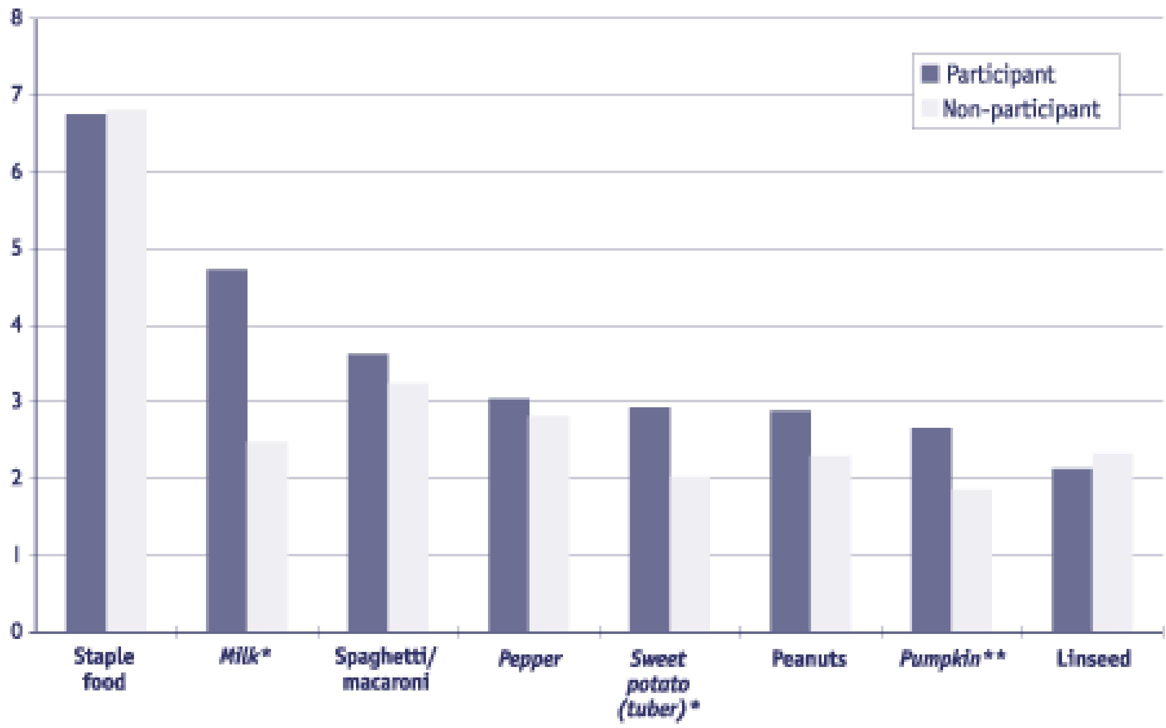
[14] It should be noted that the project did not provide inputs to promote fruit trees.

Improving children's food intake. The third pillar of the trial intervention focused on improving young children's consumption of vitamin A-rich foods, in particular fruits, vegetables, and milk. Goat-owning households tended to consume all the milk they produced; in most cases (87 percent), milk was consumed in the form of *hoja*, with only 8 percent of households consuming the milk fresh and none using it to produce yoghurt, cheese, or butter. In general, children who lived in households that participated in the trial intervention had a slightly more diversified diet than those who did not participate, as illustrated in figure 2.

Animal sources of vitamin A were consumed less than once a week, an extremely low rate. Although rare in general, intervention participants consumed egg yolk significantly more often than non-participants (0.46 versus 0.29 times per week; $p < 0.05$).[15] The food frequency score for animal sources was 1.1 (as compared to the threshold score of 4 established by HKI) for all sample children, irrespective of whether their household participated in the intervention or not. The weighted total score of 2.5 was also far below the HKI thresholds of 4 for participants and 6 for non-participants (Rosen, Haselow and Sloan 1993). Participants, however, had a significantly higher weighted score than non-participants (2.56 versus 1.59; $p < 0.01$).

Focus group participants reported that children whose diets included more vitamin A-rich foods had "clear and shining skin" and "were more strong." They also noted that repetition of information and opportunities for discussion permitted women to integrate the information and skills into their daily habits and to resolve

Figure 2. Number of times per week children under five consume key foods



*p<0.01

**p<0.05

Italicized foods = vitamin A sources

[15] Such low frequencies were not completely unexpected because data were collected during the lean season, when food availability was particularly limited.

Table 4. Prevalence of vitamin A deficiency in children under five (n)

Clinical indicator	Participation	
	Yes (509)	No (165)
Night blindness	7%	8%
Bitot's spots		
— Left eye	1%	4%
— Right eye	<0.01%	4%

problems they encountered while testing the new practices. Finally, women reported that as a result of their increased knowledge about preparing meals, they felt they could offer their families "more food" and a more diverse diet.

Reducing vitamin A deficiency. The study hypothesized that when study participants' nutritional knowledge and practices improved and food production, as well as the nutritional intake of their children, increased, they would have lower rates of vitamin A deficiency compared to non-participants. To assess this, clinical examinations were conducted on 467 children under five years of age.

The prevalence of night blindness and Bitot's spots among both participants and non-participants surpassed cut-off points (1 percent and 0.5 percent, respectively). This indicated that vitamin A deficiency was a public health problem in both groups (see table 4), although prevalence was lower among participants than non-participants. While there were no significant differences between the sexes on either indicator, the rate of night blindness was significantly higher in Kombolcha than in Gursum (10 percent versus 3 percent; $p < 0.01$). No cases of corneal xerosis, corneal ulceration, or corneal scarring were found during clinical examinations.

Multivariate Results

Multivariate analyses of post-intervention data were carried out using logistic regression. This analysis controlled for the possible confounding effects of key factors, such as ownership of goats or cattle and district of residence, on the risk of being vitamin A deficient. It also served to identify relationships between contributing factors and expected outcomes of the trial intervention.

The determinants of risk. Risk was defined by whether the index child or woman experienced night blindness or Bitot's spots in either eye. The regressions presented in table 5 relate several factors to the dependent variable, i.e., clinical signs of vitamin A deficiency. These are economic status (as measured by ownership of cattle and income from agricultural sales); the inputs of the DGDP project (goat ownership); and three components of the trial intervention (HKI scores, having a vegetable garden, and children's consumption of milk). Each column reports the coefficients of four logistic regression models that were constructed to test the contributions that the three trial intervention components made alone, as a set, and in combination with the economic and DGDP factors. These models served to explain the risk of vitamin A deficiency.

Owning a goat was not sufficient to ensure that a randomly chosen child or woman was less likely to be vitamin A deficient. Conversely, those children and women in households that owned at least one cow were less likely to be vitamin A deficient. This may not necessarily indicate that cow ownership directly reduces risk, but that it represents overall wealth, which may reduce risk. Wealthier households may be able to provide a more diversified diet and have better access to health care services. In addition, they may have greater overall income to sustain nutritional well-being during the lean season, when food insecurity is highest.

Table 5. The determinants of vitamin A deficiency[a] (standard error)

	Logistic Regression Models			
	Model 1: Economic + DGDP + dietary diversification	Model 2: Economic + DGDP + home gardens	Model 3: Economic + DGDP + milk consumption	Model 4: Economic + DGDP + all 3 intervention components
Household owns at least one cow (y/n)	-1.178** (0.515)	-1.223** (0.507)	-1.085** (0.519)	-1.075*** (0.528)
Household owns at least one goat (y/n)	-0.248 (0.516)	-0.132 (0.513)	0.028 (0.524)	0.049 (0.549)
HKI score	-0.341** (0.170)	-	-	-0.175 (0.160)
Vegetable garden (y/n)	-	-0.968 (0.655)	-	-0.688 (0.710)
Consumes milk more than four times/week (y/n)	-	-	-1.601*** (0.585)	-1.396** (0.607)
Weekly income from agricultural sales	0.049*** (0.014)	0.040*** (0.014)	0.047*** (0.014)	0.048*** (0.015)
Constant	-1.268** (0.545)	-1.737*** (0.480)	-1.576*** (0.489)	-1.140** (0.551)
N	N=283	N=283	N=283	N=283
Chi²	Chi² (4)= 17.67	Chi² (4)=14.61	Chi² (4)=20.99	Chi² (4)=24.78

*** *$p<0.01$*

** *$p<0.05$*

[a] *As measured by presence of night blindness or Bitot's spots in a child or a woman. The regressions were run on a subset of the larger sample with post-intervention HKI scores to ensure that the nested models could be compared. The coefficients remained stable when the larger sample of 402 was considered.*

An unexpected result was that the amount of weekly income derived from the sale of agricultural produce slightly increased the likelihood that a child or woman was vitamin A deficient. This may have been because those households that sold their produce during the lean season—rather than keeping it for household consumption—faced immediate cash constraints. Such households faced the risk of undermining nutritional intake directly by reducing the availability of nutrients, or indirectly through the purchase of commodities or services that do not improve vitamin A status.[16] Such a "substitution effect" may appear to be counterintuitive, but occurs in response to the complex factors that drive decisions about the allocation of scarce resources within a household.[17] Children with higher HKI scores were less likely to be vitamin A deficient, a finding that is consistent with the literature suggesting that food frequency methods can predict deficiency (Persson et al. 1998). Similarly, both milk consumption and the ownership of a vegetable garden reduced the risk of vitamin A deficiency for young children.[18]

[16] Household expenditure data collected on several items during the same week indicated that the highest cost items were maize and wheat flour, sugar, kerosene, cooking oil, grains, tobacco, and other staples.

[17] The coefficient may also reflect an income effect, whereby as income from agricultural sales increases, a shift occurs from lower prestige foods that may be micronutrient-rich to less nutritious but higher prestige foods.

[18] The multivariate analysis indicates that children who consumed milk more than four times a week had a lower risk of vitamin A deficiency. This was somewhat surprising because milk is not necessarily a good source of vitamin A, although it does contain fats that may accelerate its absorption. Milk consumption also may be proxying feeding practices that reduce vitamin A deficiency but are associated with frequent milk consumption.

A Wald test on the joint significance of the HKI score, ownership of a vegetable garden, and milk consumption rejected the hypothesis that the coefficients were jointly insignificant at the 1 percent level. A likelihood ratio test of the expanded model (see table 5) (containing both the trial intervention components and the controls) against its nested version (in which all components of the intervention were excluded) also rejected the hypothesis that the coefficients on these variables are jointly insignificant at the 0.5 percent level.[19] This suggests that an intervention package that focuses on maximizing food intake, increasing vegetable gardens, and promoting milk consumption can contribute to reducing the risk of vitamin A deficiency.

Effects of the intervention. Additional analysis of post-intervention data was undertaken to estimate the effects of the intervention on expected outcomes regarding food production, preparation, and consumption patterns (see tables 6 and 7). The ordinary least squares (OLS) regression explored those factors that contributed to a higher HKI score. The logit regression estimated the effect of key variables on the probability of three events. These were finding a child in the top quintile of the distribution of HKI scores; observing a house that both owns and uses a vegetable garden during the lean season; and reporting that a child consumes milk more than four times a week.[20] If the components of the trial intervention were effective, there would be a significant difference between participant and non-participant households for each of the expected outcomes.

Table 6 reports the regression results for key outcomes. Across all specifications, the trial intervention coefficient is highly significant. Furthermore, the intervention increased the likelihood that a household maintained a vegetable garden during the lean season and the child consumed milk more than four times a

Table 6. Effects of the trial intervention on four dependent variables (standard error)

	OLS	Logistic Regressions		
Dependent variable	**HKI score**	**Child in the top quintile of the HKI scores**	**Household had a vegetable garden**	**Child consumed milk more than 4 times/week**
Household owns at least one cow (y/n)	0.321 (0.339)	-0.194 (0.244)	-0.059 (0.267)	0.139 (0.261)
Household owns at least one goat (y/n)	-0.002 (0.318)	-0.692*** (0.234)	0.621*** (0.240)	0.076 (0.241)
Whether household participated in the intervention (y/n)	0.889*** (0.343)	0.782*** (0.256)	1.181*** (0.325)	1.029*** (0.256)
Weekly income from agricultural sales (in birr)	0.014 (0.013)	0.015 (0.009)	-0.008 (0.009)	0.008 (0.010)
Constant	1.769*** (0.371)	-0.303 (0.276)	-1.988*** (0.356)	-0.103 (0.281)
N	N=283	N=402	N=402	N=402
Chi²	F(4, 278)=2.92	Chi² (4)=21.90	Chi² (4)= 33.26	Chi² (4)=21.90

*** *p<0.01*

[19] The Wald test on ownership of a vegetable garden + milk consumption + HKI score = 0; Chi 2(4) = 6.14; Prob = 0.01. Similarly, the test of the expanded model against the nested model rejects the latter and reports that the coefficients on the three variables are significant at 0.01.

[20] Milk was not included in the HKI aggregate scores because it is not as rich a source of vitamin A as pumpkin, papaya, and carrot.

Table 7. Impact of participation in the intervention on nutritional outcomes[a]

	Participated in intervention	Didn't participate in intervention	Impact of intervention[b]
Child in the top quintile of the HKI scores	0.49	0.37	20%
Child consumed milk more than 4 times/week	0.76	0.51	22%
Household had a vegetable garden	0.38	0.13	25%

[a] *These results are adjusted for other determinants of expected outcomes.*

[b] *Differences are significant at $p<0.01$.*

week. It is therefore clear that the intervention provided household members with the means (knowledge, skills, and productive inputs) to achieve better nutrition and reduce the risk of vitamin A deficiency.

Table 7 gives the probabilities that a particular event will occur in relation to participants and non-participants and demonstrates the comparative advantage of involvement in the intervention. This table shows that a child was 20 percent more likely to score in the top quintile of the HKI scores and 22 percent more likely to consume milk at least four times a week if his/her household participated in the intervention activities. Similarly, a household was 25 percent more likely to own and maintain a vegetable garden if it was exposed to the trial intervention. Thus, participation in the intervention provided remarkably large and statistically significant nutritional benefits.

Advocacy Component

To strengthen the link between research findings and policies and programs, the FARM Africa research team developed a strategy to engage relevant stakeholders in developing and monitoring the intervention, as well as learning from the research results and applying them to respective institutions.

Building on the intervention design workshop, the study team aimed to convene a local technical advisory group to monitor and draw lessons from the intervention. Potential members included representatives of the Ministries of Agriculture, Education, and Health, the Zonal Administrative Council, UNICEF, and non-governmental organizations (NGOs) working in the area.

Unfortunately, the advocacy strategy met with only limited success for several reasons. First, it was difficult to operationalize cross-institutional collaboration given the differences in institutional mandates and how they are interpreted and applied. For example, the Ministry of Health and the Ministry of Agriculture both viewed the intervention as falling within the purview of the other. Second, the Government of Ethiopia was, at the time of the intervention, in the early stages of decentralizing public sector decisionmaking, causing some confusion regarding areas of responsibility.

Interest in the intervention was greatest on the part of school staff members and the Zonal Education authorities, whose central offices had already designated responsibility to schools for promoting school gardens. The Zonal Administrative Council was also enthusiastic, given its mandate to coordinate programs across Ministries and sectors, but did not have the authority to ask staff from the different Ministries to take on activities that their Ministries had not endorsed.

While the Council would (in a fully decentralized system) be the seat for coordinating activities, necessary procedures and policies had not yet evolved or been established. It is likely that, over time, the Council will be in a better position to play an inter-sectoral coordinating role and thereby make collaboration easier and more efficient.

Because the UNICEF regional office was closed down midway through the study, a potential nonpartisan convening mechanism was lacking. These difficulties prompted FARM Africa and the AUA to focus their efforts on engaging representatives in key activities, including training of field agents and developing key messages. This was viewed as the best way to strengthen the technical elements and increase awareness of the intervention. It was not possible, however, to collect data to assess whether this approach resulted in a change in policies or programs in any of the Ministries or other agencies that participated.

Children from a participating household are diagnosed with Bitot's spots

Discussion

The trial intervention was designed to test the effects of providing women with physical inputs, skill training, and health and nutrition education, and thereby to complement the DGDP. These resources were considered necessary to enhancing agricultural production and care-giving activities, including feeding practices, and, in turn, to improve food intake and reduce vitamin A deficiency. The results discussed above highlight several important issues, as follows.

Investing in Women

A fundamental assumption of the intervention was that putting resources in the hands of those household members who are most central to family nutrition would improve nutrition. It is clear that women play critical roles in this regard because they earn income, produce, process and prepare food, feed and care for children and take them to health services, and are often responsible for household and environmental sanitation. The intervention results underscore the benefits of providing women with resources to improve agricultural production and food consumption: the number of home gardens increased; children consumed more milk and food; and the risk of vitamin A deficiency differed significantly between study participants and non-participants.

This consistent and positive trend suggests three things. First, while agriculture-focused inputs can increase production, they do not necessarily lead directly to improved consumption. Second, inputs specifically aimed to increase consumption are needed in order to yield nutritional benefits. Third, providing women with a package of resources enables them to both produce food and feed it to their families. Thus, investing in reducing women's resource constraints is one way to link agricultural production to human nutritional outcomes.

Selection of Interventions

Foods promoted through the intervention that contributed most to participants' weighted total food scores included milk, pepper, sweet potato, pumpkin, and egg yolk. Given the high cost of animal food products in this region, promotion of fruits and vegetables, particularly those with a high level of bio-available vitamin A, was an appropriate avenue of intervention.

While participation in the women-focused, food-based interventions had significantly important nutritional effects, food frequency scores remained far below the cut-off point for defining risk of vitamin A deficiency. This suggests that household food insecurity (including lack of economic and physical access to available food) must be addressed in order to make any significant strides towards improving vitamin A deficiency through a food-based intervention.

Since food alone can not overcome such serious deficiencies in the short term, it is important to consider the feasibility of using vitamin A capsules. Unfortunately, this part of Ethiopia lacks a community health care structure and has an unreliable supply of the supplement. Public sector agencies, NGOs, and donors will have to take immediate action to overcome logistical and operational problems in order to distribute vitamin A capsules to these high-risk communities.

FARM Africa has begun this process by sharing the results of both the baseline and post-intervention surveys with relevant agencies and government offices. The Ministry of Health, UNICEF, and other agencies responsible for health service delivery systems will also have to take action. The success of the food-based intervention in the face of such constraints suggests that efforts must be made to promote long-term, sustainable strategies, even while addressing the problem in the short-term.

Measuring Nutritional Benefits

This study used the HKI food frequency method to measure differences between participants and non-participants. The method is reliable and relatively easy to use. While it has been validated in relation to serum retinol, it was principally developed to identify communities at risk of vitamin A deficiency, i.e., to assess prevalence. To the knowledge of the authors, it has not been used to evaluate changes in vitamin A deficiency, as in this study. Nonetheless, this study presumed that a positive change would suggest a reduction of vitamin A deficiency; the use of the HKI method in this context merits further study.

Limiting Factors

Three factors may have limited the achievements of this community-based intervention: a short time frame, seasonal effects, and the selection of beneficiaries. First, the intervention period was only nine months, insufficient time to measure results that were principally based on behavior change. If more time had been available to work with the women and to reinforce the lessons learned through the trial intervention, greater change might have been achieved.

Second, food intake data were collected during the lean season, when food is least available. Thus, the results should be cast in terms of being the "worst case" scenario of nutritional status in this area. Again, if time had allowed for the collection of data when food was more plentiful, a comparison of results during two different seasons might have elucidated the intervention's full range of potential effects.

Finally, FARM Africa's decision to work with the "poorest of the poor" (those without livestock) may have had a limiting effect. Such households start at a greater disadvantage in terms of the scope and scale of constraints that limit their ability to achieve nutritional and economic well-being. They are also more risk-adverse and less likely to adopt new practices.

Thus, the expanded technology package (a combination of goats, seeds, knowledge, and skills) was not sufficient to overcome the enormous need among the poorest households. While the gains made in improving the intake of vitamin A and other nutrients through both the DGDP and the trial intervention are encouraging, it is also clear that interventions aiming to improve household well-being must attempt to alleviate poverty as well as to enhance food availability.

Recommendations

The results of this study strongly suggest that it is technically and operationally possible to integrate agriculture and livestock interventions with health and nutrition strategies at the community level, and that such an integrated package can contribute to vitamin A intake and lower the risk of vitamin A deficiency. The following recommendations derive from the results of both the DGDP and the current trial intervention study.

■ **Extend vitamin A supplementation services to the study area.** When it became clear that alarming levels of vitamin A deficiency existed in the study area, FARM Africa immediately called the attention of Ministry of Health officials to the need to expand vitamin A supplementation activities. However (as mentioned above), the lack of a community-based health service delivery system in this area and the irregular supply of vitamin A capsules limits the Ministry's ability to respond to this critical problem. FARM Africa and other actors should continue to encourage the Ministry to resolve these issues and to focus some of its scarce resources on the Eastern Hararghe Zone.

■ **Support achieved gains.** This food-based, community education trial intervention improved vitamin A intake and increased milk consumption among young children. These are important achievements in the face of the study area's general state of food insecurity. Further, the greatest improvements appeared to cluster among households that were not the "poorest of the poor."

To extend benefits to these and other communities, FARM Africa should continue to provide the integrated technology package to encourage those households most at risk to adopt the promoted practices and to ensure that a greater number of households can consolidate their gains. In addition, relevant Ministries, nongovernmental and community-based organizations, and donor agencies that work in nutrition and food security should consider developing similar integrated intervention packages.

■ **Focus on the household and the role of women.** While the trial intervention did not target only women, the activities drew in more women than men. Despite the fact that women are essential to household economies and agricultural production, they function within a context that creates numerous constraints.

It is important for FARM Africa and others working at the community level to continue to increase women's access to the resources they need to enhance their contributions to nutrition. It is also critical to focus attention on increasing men's understanding of how they can ensure their families' health and nutrition and support women's economic, agricultural, and care-giving roles.

■ **Explore sweet potato production and consumption.** Sweet potatoes are a central part of the diet in the study area and are, in fact, often consumed in the absence of other, preferred foods or during times of crop failure. The AUA has a number of sweet potato varieties that can be tested with regard to beta carotene content and other characteristics that are important to both producers and consumers.

In addition, because extension agents working for the Ministry of Agriculture continue to work in the study communities, the opportunity exists to promote this potentially important food crop to local farmers. Thus, efforts should be made by Zonal Authorities and the AUA (with donor support) to build a long-term, sustainable solution to micronutrient deficiencies and food insecurity by focusing on the production and promoting the consumption of sweet potatoes.

■ **Encourage institutional collaboration.** Working with the Government of Ethiopia, donor agencies should encourage cross-sectoral efforts to reduce food insecurity in a gender-sensitive manner. Institutions should be identified with regard to their comparative advantages and representatives should then be brought together to discuss what each entity can do to foster collaboration on shared problems. Given that the Government of Ethiopia is in the midst of a decentralization process, it will be important to ensure that Zonal Administrative Councils are empowered to initiate and coordinate such collaboration. This would place the critical responsibility for planning and acting in an integrated manner on the administrative level closest to the community.

Three generations enjoy their goats and improved nutrition

Appendix A: Explanation of Methodology

Survey questionnaires and focus group guides were reviewed, pretested, and administered by trained enumerators and supervisors. Informed consent was obtained from all sample households. Except in a few cases where women were not available, respondents were adult women, generally mothers of the index children (selected randomly from all children under five years of age in the household). Two field nutritionists supervised the data collection and field operations and checked raw data. In cases of missing data, enumerators returned to households to complete the data collection form. Focus groups were led by the team member from AUA, who also analyzed the resulting text.

Anthropometric data were collected for the index children. Weight was measured to the nearest 100 grams using bathroom scales for older children and hanging scales for younger ones. Scales were checked and calibrated with a known weight at the start of each day and at regular intervals throughout the day. Height was measured to the nearest half centimeter using a graduated height stick with a moveable headpiece for older children and, for children who could not yet walk, in a supine position using a calibrated measuring board. Mothers reported age, with cross-referencing done using key local or national events in doubtful cases. Weight-for-height, weight-for-age, and height-for-age z-scores were calculated using EPI Info software. The -2.0 standard deviation score was used as the cut-off for relevant indicators of malnutrition.

Outcome indicators included food intake (HKI score) and clinical signs of vitamin A deficiency among children under five. The HKI food frequency method was used as a dietary measure to examine differences in vitamin A intake between groups. To develop the food frequency questionnaire, a list of locally-available food items known to be rich in vitamin A or high fat content (a quality that enhances absorption of vitamin A) was prepared based on a market survey and key informant interviews.

Using the questionnaire, respondents were asked how many times in the past week that child had consumed any of the food items. These were tallied by source, i.e., plant or animal.[21] The total score for plant sources was divided by six and added to the sum of the animal sources to arrive at a weighted total HKI score. The total weighted scores were then divided by number of respondents to obtain the mean frequency of total consumption of these vitamin A food sources. Because availability of vitamin A-rich foods tends to be seasonal, baseline and post-intervention data were collected during the same months of the calendar year.

Clinical signs of vitamin A deficiency included self-reported cases of night blindness and physical examination for Bitot's spots and corneal xerosis. Mothers were asked about their children's and their own night blindness. Health care personnel trained in identifying Bitot's spots and corneal xerosis examined all index children at both baseline and post-intervention.

Multivariate ordinary least squares (OLS) regression analysis was performed to explain observed variations in the weighted total HKI scores from the post-intervention survey.[22] A logistic regression was used to assess the contribution of

[21] Plant origin foods included in the score were pepper, dark green leafy vegetables (non-specific), carrot, mango, pumpkin, Swiss chard, papaya, amaranthus, sweet potato tubers and leaves, avocado, and red palm oil. Animal sources included egg yolk, fish, liver, butter, and cod liver oil.

[22] The multiple regression analysis was first attempted on the changes in the total weighted HKI scores between the baseline (March 1996) and final (March 1998) surveys. This proposition was found to be weak on the ground that the same index child was not used as a reference. As a result, the comparison of scores and regression analyses were limited to the HKI scores from the post-intervention survey.

selected relevant variables to desired outcomes. Dependent variables were the probability of having an HKI score in the top 20 percent, owning and using vegetable gardens, and consumption of milk by the index child at least four times a week. The variables evaluated in the analysis included:

- participation in the trial intervention;
- presence of a vegetable garden in the household during the final survey;
- maintenance of a vegetable garden for the past two years;
- ownership of goats, crossbred goats, or cattle;
- total holding of cultivated land;
- consumption of milk by the household during the final survey;
- frequency of consumption of any milk by the index child during the week prior to the survey;
- per capita expenditure for purchase of food items and supplies during the week prior to the survey;
- per capita sales income from the sale of agricultural produce during the week prior to the survey;
- presence in the household of a child going to school;
- family size; and
- the index child's sex and age in months.

Given the high prevalence of vitamin A deficiency in the study area, the results of the clinical assessment of deficiency for both the index child and his/her mother were aggregated into risk scores (0,1) for the household. The risk scores were then subjected to a multivariate logistic regression analysis that considered the above variables as determinants of risk.

As a result of the intervention, vitamin A-rich vegetables are grown for household consumption

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