Contents

Iron fortification

Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: A population-based intervention trial —J. Chen, X. Zhao, X. Zhang, S. Yin, J. Piao, J. Huo, B. Yu, N. Qu, Q. Lu, S. Wang, and C. Chen 177
Commentary on "Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: A population-based intervention trial" —N. S. Scrimshaw and G. R. Gleason 187

Nutrition in the elderly

Chile's national nutritional supplementation program for older people: Lessons learned —A. D. Dangour, X. Moreno, C. Albala, A. Rivera-Marquez, L. Lera, A. Villalobos, S. S. Morris, and R. Uauy 190

Vitamin A consumption

Nutrition knowledge and practices, and consumption of vitamin A–rich plants by rural Nepali participants and nonparticipants in a kitchen-garden program —K. M. Jones, S. E. Specio, P. Shrestha, K. H. Brown, and L. H. Allen 198

Maternal factors in child nutrition

Stunted child–overweight mother pairs: Prevalence and association with economic development and urbanization —J. L. Garrett and M. T. Ruel 209
Maternal employment and income affect dietary calorie adequacy in households in Sri Lanka —I. M. Rathnayake and J. Weerahewa 222

Short communication

The effect of family structure on a sample of malnourished urban Nigerian children —L. Adekunle 230

Letter to the Editor

In response to Gargari et al., "Prevalence of overweight and obesity among high-school girls in Tabriz, Iran, in 2001" —P. Wickramasinghe 234
Author's response: B. P. Gargari 235

Food and nutrition policy

What can food policy do to redirect the diet transition? (IFPRI Discussion Paper Brief 165) —L. Haddad 238
From research to program design: Use of formative research in Haiti to develop a behavior change communication program to prevent malnutrition (IFPRI Discussion Paper Brief 170) —P. Menon, M. T. Ruel, C. Loechl, and G. Pelto 241

Book reviews 243

News and notes 246

In memoriam 250

Food and Nutrition Bulletin

Editor: Dr. Irwin H. Rosenberg, Friedman School of Nutrition Science and Policy, Tufts University, Boston, Mass., USA
Senior Associate Editor: Dr. Nevin S. Scrimshaw
Associate Editor—Food Policy and Agriculture:
Dr. Suresh Babu, International Food Policy Research Institute (IFPRI), Washington, DC, USA
Associate Editor—Food Science and Technology: Dr. V. Prakash, Central Food Technological Research Institute (CFTRI), Mysore, India
Statistical Advisor—Dr. William M. Rand, Tufts University School of Medicine, Boston, Mass., USA
Managing Editor: Ms. Susan Karcz
Manuscripts Editor: Mr. Jonathan Harrington
Copyeditor: Ms. Ellen Duff
Editorial Assistant: Ms. Shauna Sadowski

Editorial Board:
Dr. Ricardo Bressani, Institute de Investigaciones, Universidad del Valle de Guatemala, Guatemala City, Guatemala
Dr. Hernán Delgado, Director, Institute of Nutrition of Central America and Panama (INCAP), Guatemala City, Guatemala
Dr. Cutberto Garza, Professor, Division of Nutritional Sciences, Cornell University, Ithaca, N.Y., USA
Dr. Joseph Hautvast, Secretary General, International Union of Nutritional Sciences (IUNS), Department of Human Nutrition, Agricultural University, Wageningen, Netherlands
Dr. Peter Pellett, Professor, Department of Food Science and Nutrition, University of Massachusetts, Amherst, Mass., USA
Dr. Zewdie Wolde-Gabreil, Director, Ethiopian Nutrition Institute, Addis Ababa, Ethiopia
Dr. Aree Valyasevi, Professor and Institute Consultant, Mahidol University, Bangkok, Thailand

Food and Nutrition Bulletin, vol. 26, no.2
© The United Nations University, 2005
United Nations University Press
Published by the International Nutrition Foundation for The United Nations University
53-70 Jingumae 5-chome, Shibuya-ku, Tokyo 150-8925, Japan
Tel.: (03) 3499-2811 Fax: (03) 3406-7345
E-mail: mbox@hq.unu.edu
ISSN 0379-5721
Design and production by Digital Design Group, Newton, MA USA
Printed on acid-free paper by Webcom Ltd., Toronto, ON Canada

Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: A population-based intervention trial

Junshi Chen, Xianfeng Zhao, Xin Zhang, Shian Yin, Jianhua Piao, Junshen Huo, Bo Yu, Ning Qu, Qiliang Lu, Shisun Wang, and Chunming Chen

Abstract

The objective of this research was to study the effectiveness of NaFeEDTA-fortified soy sauce for controlling iron deficiency in a high-risk population. This was an 18-month, randomized, placebo-controlled intervention trial in 14,000 residents aged three years or older in Bijie City, Guizhou Province, China, using sodium-iron ethylene diamine tetraacetate (NaFeEDTA)-fortified soy sauce (29.6 mg Fe/100 ml). The study data included measurements of food consumption, hemoglobin, serum ferritin, and serum retinol. The results showed that the diet consisted primarily of cereals, fruits, and vegetables, with very little meat. Food consumption remained unchanged during the study period and was similar in the fortified and control groups. The average daily soy sauce consumption of the group consuming the fortified product was 16.4 ml per person, which provided 4.9 mg of iron from NaFeEDTA. At the end of the trial, all age and sex subgroups receiving NaFeEDTA had significantly higher hemoglobin levels, a lower prevalence of anemia, and higher plasma ferritin levels than the controls. The effects became statistically significant after six months of intervention and were maintained throughout the study period. We conclude that NaFeEDTA-fortified soy sauce was highly effective in controlling iron deficiency and reducing the prevalence of iron-deficiency anemia in men, women, and children. NaFeEDTA-fortified soy sauce is affordable and was well accepted by the study population.

Junshi Chen, Xianfeng Zhao, Xin Zhang, Shian Yin, Jianhua Piao, Junshen Huo, Bo Yu, and Ning Qu are affiliated with the Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing. Qiliang Lu is affiliated with the Bijie City Sanitary and Anti-epidemic Station, Guizhou, China. Shisun Wang is affiliated with the Guizhou Provincial Center for Disease Control and Prevention, Guiyang, China. Chunming Chen is affiliated with the Chinese Center for Disease Control and Prevention, Beijing.

Please direct queries to the corresponding author: Dr. Junshi Chen, Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, 29 Nan Wei Road, Beijing 100050, China; e-mail: jshchen@ilsichina.org.

Mention of the name of firms and commercial products does not imply endorsement by the United Nations University.

Key words: Anemia, iron deficiency, iron fortification, NaFeEDTA, soy sauce

Introduction

Iron deficiency is ranked at the top of the three global "hidden hungers," with about one-fifth of the world's population suffering from iron-deficiency anemia [1]. Malnutrition related to inadequate protein, fat, and energy consumption was essentially eliminated in China by the late 1990s. However, micronutrient deficiency states remain a major nutritional problem. Iron deficiency is widespread in China, affecting most segments of the population. The overall prevalence of anemia in the 1990s was 10% to 30%, with the highest rates in children, women, and the elderly [2]. The 2000 Nutrition Survey found that the prevalence of anemia in six-month-old infants was 28% in urban areas and 50% in rural areas. In women of childbearing age, the prevalence was 28% in urban areas and 41% in rural areas [3]. Sun et al. [4] reported that the prevalence of anemia in 6- to 17-year-old children and adolescents in Shanghai in 2002 was 21.6% (17.2% in the inner city and 24.3% in the suburbs). In most cases, iron-deficiency anemia in China is caused by the low bioavailability of iron in the plant-based diet.

It is now widely recognized that both iron deficiency and iron-deficiency anemia have adverse effects on health, including growth retardation and impaired cognitive development in children, increased susceptibility to infectious diseases, and reduced productivity in adults. Ross et al. [5] estimated that the loss of productivity due to childhood and adult anemia in 2001 accounted for 3.6% of the Chinese national gross domestic product. Therefore, the implementation of effective measures for controlling iron deficiency and iron-deficiency anemia is an important public health issue that is relevant to the further development of the national economy in China.

Food fortification is recognized as an important strategy for controlling micronutrient deficiencies. Its advantages include effectiveness, low cost, the potential for rapid implementation, and the possibility of covering wide geographic areas and most subpopulations. One of the best examples of successful food fortification is salt iodination.

Our previous work has demonstrated the following:

» Soy sauce is a commonly used condiment in all parts of China, in both urban and rural settings. It is an important component of the Chinese diet. More than 70% of households consume soy sauce. Most soy sauce preparations are produced by industry in China, and there is a trend toward consolidation in the soy sauce industry. Moreover, the amount of soy sauce consumption is self-limited, so excessive intake of iron is unlikely.
» The percentage of iron absorption from sodium-iron ethylene diamine tetraacetate (NaFeEDTA) in soy sauce (10.5%) was more than twice that of ferrous sulfate in adult females in a study that employed stable isotopes [6].
» NaFeEDTA does not cause organoleptic changes in soy sauce, and it is stable at room temperature for at least 18 months [7].
» A therapeutic trial was conducted in anemic schoolchildren. The daily administration of 5 mg of iron from NaFeEDTA in 5 ml of soy sauce cured all the cases of anemia in three months, and iron stores were significantly increased [8].

NaFeEDTA has been approved as a nutrient fortificant for soy sauce by the Chinese Government. However, before NaFeEDTA fortification of soy sauce could be considered as a potential national strategy for improving iron nutrition in China, it was necessary to conduct a large-scale effectiveness trial in a population at high risk for iron deficiency and iron-deficiency anemia to demonstrate that it could reduce the prevalence of anemia and to test its acceptance by the people. Therefore, this 18-month intervention trial was conducted between 2000 and 2003 in Bijie City in Guizhou Province, in collaboration with the International Life Sciences Institute (ILSI), the ILSI Center for Health Promotion (CHP), and the ILSI Focal Point in China.

Methods

Subjects

The Haizijie Town of Bijie City, Guizhou Province, was selected as the study site. Nine villages in the Haizijie Region were randomly assigned to one of two groups. The fortified group was provided with NaFeEDTA-fortified soy sauce and the control group with nonfortified soy sauce. The two groups of villages were evenly distributed on either side of a small road. The total number of persons three years old or older in the study site was about 14,000, living in 3,000 households. The numbers of people in the two experimental groups were similar. Four villages (6,332 residents) served as controls, and five villages (7,684 residents) received the fortified product. Most of the adults were farmers. Oral consent for participation was obtained from each participant by village leaders and doctors, after several village meetings had been held to explain the significance and methods of the trial. Village residents could elect not to participate in the trial.

The study was approved by the institutional review board of the Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, prior to the start of the trial.

Study design

The study was a randomized, double-blinded, controlled intervention trial. The subjects in the fortified group were given iron-fortified soy sauce, whereas those in the control group were given nonfortified soy sauce of the same brand and quality. Both the fortified and the nonfortified soy sauces were provided by the Beijing Huwang-Hetiankuan Food Company in Beijing. The concentration of iron added to the fortified soy sauce was 29.6 mg of iron per 100 ml as NaFeEDTA. Food-grade NaFeEDTA was manufactured and provided by the Beijing Vita Company. The quality of the NaFeEDTA was in compliance with the Joint Expert Committee on Food Additives (JECFA) specifications [9]. The soy sauces were distributed to the participants once a month on a household basis by designated village staff members. The households were provided with enough soy sauce to allow for a daily consumption of 15 ml by each family member. Detailed distribution records were maintained throughout the study. The intervention was continued for 18 months.

Sampling procedures

About one-third of the participants were invited to take part in the evaluation protocol. The sampling protocol was based on students in the local schools. When one student was selected, the whole family to which the student belonged was selected. The school class was the basic unit of sampling, and the sampling continued class by class until the number of samples for each village and the group (active or control) reached approximately one-third of the whole population in that age and sex subgroup (age and sex proportional to natural population distribution). Persons selected for the evaluation protocol were then used as the assessment cohort and asked to provide blood samples at baseline and at 6, 12, and 18 months.

Dietary assessment

Individual food-frequency questionnaires (FFQs) were administered four times (at baseline and at 6, 12, and 18 months) to all subjects on a selected household basis. For comparison of consumption between the two groups of subjects, the foods were classified into five groups: cereals, legumes, vegetables and fruits, animal foods, and oils and fats. The dietary iron intake was calculated from the Chinese Food Composition Tables [10].

Biochemical assays

Hemoglobin (cyanmethemoglobin method, standard supplied by Sigma, St. Louis, MO, USA, and Q/C sample by DiaMed AG, Cressier, Switzerland), plasma ferritin (radio immunoassay kit, Beijing Atomic Energy Institute), and plasma retinol (high-performance liquid chromatography, C18 reverse-phase column, 98% alcohol, 2% water, UV 325 nm detector [11]) were measured in venous blood samples (with the exception of three- to six-year-old children, where capillary blood was used and the assays were limited to hemoglobin measurements) at baseline and 12 months. Hemoglobin measurements were also performed on capillary blood samples at 6 and 18 months in the other age and sex subgroups. Duplicate samples were analyzed for hemoglobin, plasma ferritin, and (in selected samples) plasma retinol.

A working manual was prepared and used as the training material for the local working team. A three-day training course was convened in Bijie City for about 30 local team members, and the trainees carried out a pilot baseline survey on the last day of the training course. All of the methods used in this study were piloted and/or validated. Analytical standards and blind samples were used in all laboratory analyses. FFQs were checked by local team leaders before data entry. All data were double entered. Logistic checking and range checking were conducted at the Institute of Nutrition and Food Safety in Beijing. Data analysis was conducted by analysis of variance (ANOVA) with the Statistical Package for the Social Sciences (SPSS).

Results

The data were divided into the following age and sex subgroups: 3 to 6 years (preschool), 7 to 18 years (school), 19 to 54 years (adult), and 55 or more years (elderly). Each subgroup was divided according to sex, and the adult female subgroup was further divided into two age subgroups: 19 to 30 years and 31 to 54 years. The data for preschool boys and girls were combined in some data sets because of the small number of subjects in this subgroup.

The total number of subjects in each of the nine age and sex subgroups at the baseline survey represented approximately one-third of the whole population in that age and sex subgroup. The evaluation cohort was therefore representative of the whole population. The numbers of subjects in the various subgroups were reduced slightly during the subsequent follow-up. For example, the dropout rate for hemoglobin assays was 14% in the fortified group as a whole and 6% in the control group during the 18 months of intervention. The main reasons for dropping out were that some subjects were not available at the time of follow-up examinations or were working out of town.

Dietary assessment and soy sauce consumption

The diets of all participants were similar in all age and sex subgroups and were predominantly composed of cereals, fruits, and vegetables, with only small quantities of legumes, animal foods, and fats and oils. For example, **figure 1** shows the dietary pattern of 19- to 54-year-old male subjects. The major types of cereals consumed were rice (40%), corn (33%), and fresh sweet potato and potato (18%); rice and corn were not highly refined. The vitamin C intake in the same age and sex subgroup was around 100 mg per person per day, mainly from vegetables. However, vegetables were usually stir-fried or boiled. There were no significant differences in food intake or food-preparation methods between any of the fortified and control groups or between the beginning and end of the trial period. The results for the dietary surveys in the two subgroups at greatest risk for iron deficiency (3- to 6-year-old children and 19- to 30-year-old women) at baseline and 12 months are shown in **figure 2**. The decrease in consumption of animal food after one year in both the fortified and the control groups may be due to seasonal fluctuations, because the baseline survey covered the previous 12 months and the one-year survey covered only the previous 6 months. The estimated total dietary iron intake was high and met or exceeded the recommended daily allowance (RDA) [12] in all subgroups (**table 1**). However, the small proportion of food from animal sources and the high cereal content of the diet make it likely that the bioavailability of iron is very low.

During the trial period, the mean soy sauce consumption increased from 14.3 to 16.4 ml/person/day in the fortified group and from 14.1 to 15.8 ml/person/day in the control group. The actual amount of soy sauce consumed for each age and sex subgroup is not available, because the cooking was done on a household basis. It was not possible to collect individual soy sauce consumption data. No other soy sauce was brought into

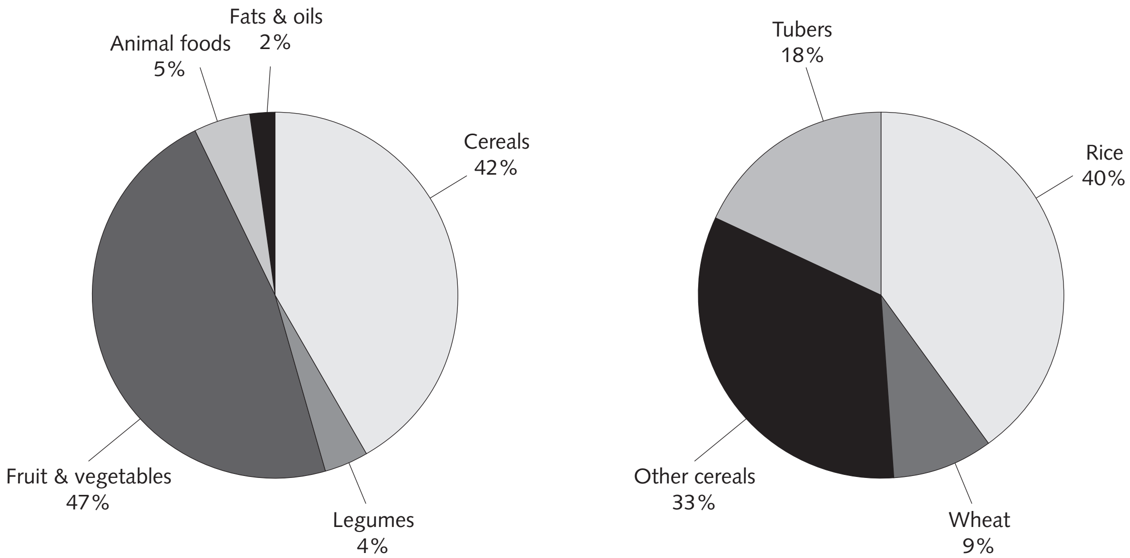

FIG. 1. Food-consumption pattern of 19- to 54-year-old men

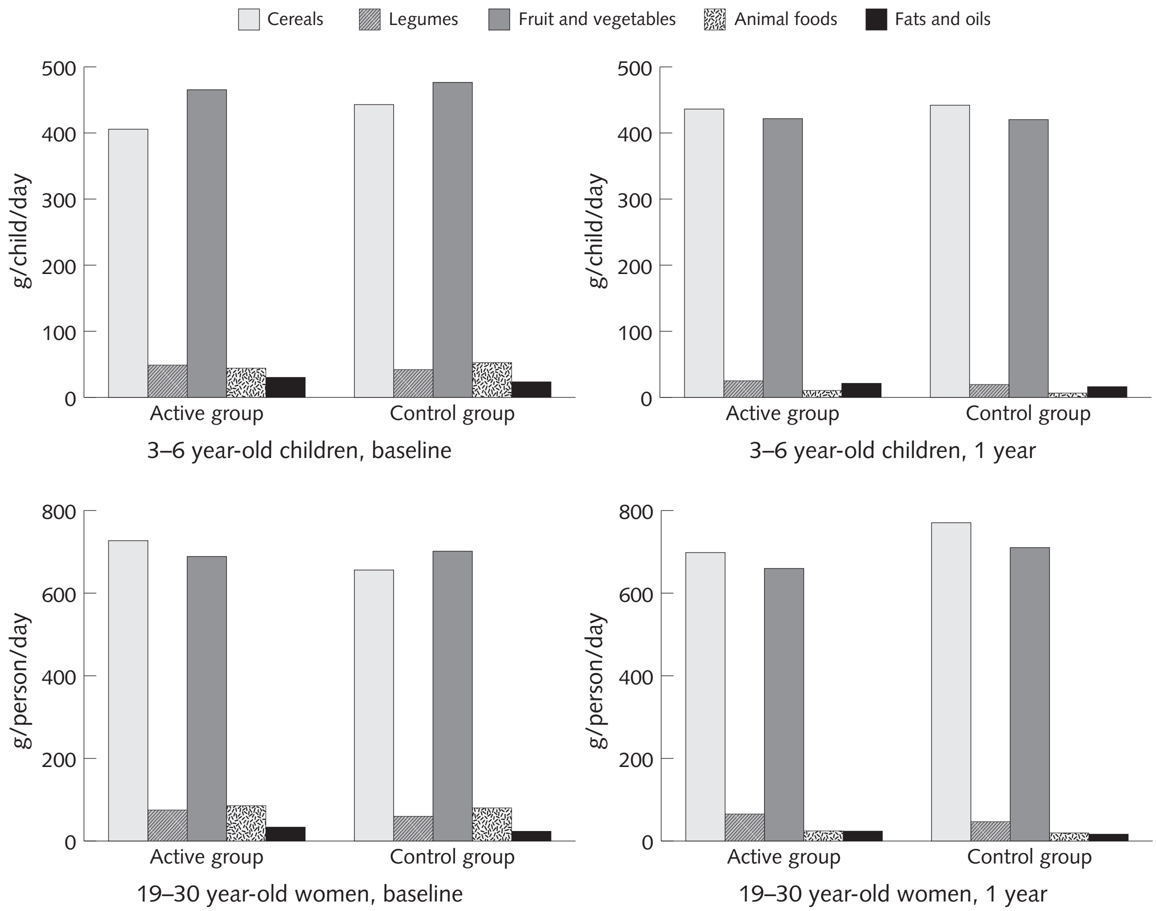

FIG. 2. Changes in food consumption (g/person/day) between baseline and one year for 3- to 6-year-old children and 19- to 30-year-old women

TABLE 1. Mean (± SD) dietary iron intake in the baseline survey according to sex and age of subjects

Sex and age	Fortified group			Control group		
	n	Fe intake (mg/person/day)	% of RDA[a]	*n*	Fe intake (mg/person/day)	% of RDA[a]
Both sexes						
3–6 yr	86	14.9 ± 7.4	124	52	16.2 ± 7.2	135
Males						
7–18 yr	178	18.8 ± 7.2	111	158	19.7 ± 8.5	116
19–54 yr	252	27.5 ± 15.0	183	235	27.4 ± 12.2	183
55+ yr	50	23.7 ± 8.1	158	52	23.4 ± 12.4	156
Females						
7–18 yr	169	19.0 ± 6.8	100	124	20.5 ± 13.3	108
19–30 yr	85	23.9 ± 10.1	120	83	23.0 ± 8.1	115
31–54 yr	213	23.9 ± 8.5	120	245	24.1 ± 15.1	121
55+ yr	46	22.1 ± 9.9	147	46	20.5 ± 6.1	137

a. Recommended daily allowances (RDAs) of iron: 12 mg for 3- to 6-year-old children, 17 mg for 7- to 18-year-old males, 19 mg for 7- to 18-year-old females, 15 mg for 19- to 54-year-old men, 20 mg for 19- to 54-year-old women, and 15 mg for persons over 54 years of age [18].

the nine villages. All of the village stores discontinued the sale of soy sauce at the beginning of the trial, and no evidence was discovered of exchange of soy sauce between villages. The average consumption values are slightly higher than the planned 15 ml/person/day, because each household was supplied with one bottle (500 ml) per month for each household member, i.e., 16.4 ml (range, 16.1–16.7) per day. The actual measured iron concentration of the fortified soy sauce was 23 mg/dL (range, 21–25). Therefore, persons in the fortified group consumed on average an additional 4.9 mg (range, 4.7–5.1) of iron per day.

A survey of the organoleptic qualities and acceptance of the fortified and unfortified soy sauce was conducted in 187 households. Both products were considered

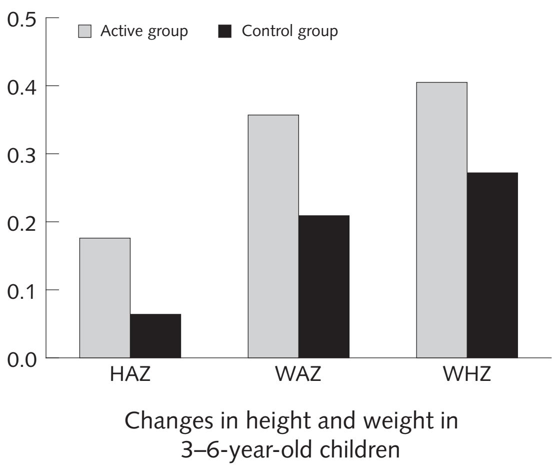

FIG. 3. Changes in height and weight of three- to six-year-old children between baseline and one year after intervention. HAZ, height-for-age Z score; WAZ, weight-for-age Z score; WHZ, weight-for-height Z score. *$p < .05$ compared with control group

to be of high quality. There were no complaints of adverse effects. The two sauces were reported to taste the same.

Anthropometric evaluation

The results from the three- to six-year-old subgroup show that the height and weight of the fortified subjects were marginally significantly lower than those of the control subjects at the baseline survey. However, after one year of intervention, the Z scores of weight-for-age, weight-for-height, and height-for-age in the fortified subjects were higher than those in the control subjects (**fig. 3**), but only the difference in weight-for-age was statistically significant, possibly because of the limited sample size and the limited duration of the trial. Height and weight were measured for every subject in all the age and sex subgroups who gave blood. No significant results were found for other age and sex subgroups.

Hemoglobin values and prevalence of anemia

There were no significant differences between the hemoglobin values in most of the age and sex subgroups of the fortified and control groups at baseline. The mean hemoglobin levels were significantly higher than the baseline values in each of the age and sex subgroups of the fortified group at six months (**table 2**). An additional small increase was observed at 12 months, with little change afterward. The hemoglobin levels also increased from the baseline values in some age and sex subgroups of the control group, but the increases were much lower than those in the fortified group. The mean hemoglobin levels were significantly higher in the fortified group than in the control group for all sex and age subgroups at all sampling times, except for men aged

TABLE 2. Mean ± SD (no. of subjects) changes in blood hemoglobin levels (g/L) during the trial

Males					
Group	Time of measurement	Age			
		3–6 yr	7–18 yr	19–54 yr	55+ yr
Fortified	Baseline	111.2 ± 11.6 (120)	120.2 ± 11.9 (481)	133.4 ± 11.5* (486)	126.2 ± 13.2 (88)
	6 mo	120.4 ± 10.0[c] (94)	131.0 ± 10.4[c]*** (449)	144.6 ± 11.6[c]*** (357)	134.4 ± 14.2[c] (89)
	12 mo	120.9 ± 8.5[c]* (107)	131.6 ± 10.7[c]*** (420)	145.0 ± 10.1[c]*** (390)	137.6 ± 12.6[c] (76)
	18 mo	118.1 ± 9.2[c]** (116)	130.2 ± 11.6[c]*** (397)	143.2 ± 10.5[c]*** (357)	135.0 ± 11.3[c]** (89)
Control	Baseline	112.8 ± 9.8 (88)	121.6 ± 10.9 (474)	135.2 ± 11.1 (424)	128.3 ± 13.2 (86)
	6 mo	117.9 ± 8.9[b] (62)	126.4 ± 11.6[c] (415)	140.0 ± 11.9[c] (305)	130.4 ± 11.9 (72)
	12 mo	116.8 ± 10.7[a] (61)	127.8 ± 10.7[c] (466)	139.8 ± 10.9[c] (387)	134.1 ± 12.2[b] (87)
	18 mo	113.5 ± 8.8 (70)	127.3 ± 11.0[c] (496)	137.7 ± 11.0[b] (345)	130.4 ± 11.2 (91)

Females						
Group	Time of measurement	Age				
		3–6 yr	7–18 yr	19–30 yr	31–54 yr	55+ yr
Fortified	Baseline	110.8 ± 10.6 (89)	118.4 ± 10.9 (398)	116.7 ± 11.1* (165)	116.6 ± 10.3*** (417)	116.3 ± 10.3 (100)
	6 mo	121.2 ± 11.3[c] (71)	127.0 ± 9.6[c]*** (376)	129.0 ± 9.8[c]** (122)	125.9 ± 10.9[c]*** (403)	127.8 ± 10.5[c]** (94)
	12 mo	121.8 ± 9.1[c] (75)	128.8 ± 8.8[c]*** (347)	129.5 ± 9.3[c]*** (115)	128.9 ± 9.2[c]*** (386)	127.8 ± 9.5[c]*** (82)
	18 mo	118.3 ± 9.1[c]* (86)	128.4 ± 10.9[c]*** (381)	128.7 ± 10.4[c]*** (124)	127.2 ± 9.3[c]*** (381)	123.5 ± 9.9[c]* (89)
Control	Baseline	113.9 ± 9.6 (67)	118.2 ± 9.2 (353)	119.4 ± 9.2 (147)	119.4 ± 9.0 (413)	115.9 ± 10.6 (83)
	6 mo	118.3 ± 10.3[a] (43)	123.4 ± 10.5[c] (319)	125.1 ± 10.5[c] (88)	122.4 ± 10.2[c] (369)	120.2 ± 9.4[c] (71)
	12 mo	119.2 ± 10.3[b] (46)	123.9 ± 8.9[c] (365)	123.2 ± 9.2[b] (139)	124.8 ± 9.2[c] (435)	121.7 ± 11.3[b] (89)
	18 mo	114.7 ± 9.0 (56)	124.8 ± 10.0[c] (377)	122.9 ± 10.8[b] (99)	122.5 ± 9.4[c] (381)	120.2 ± 9.4[b] (92)

* $p < .05$, ** $p < .01$, *** $p < .001$ compared with control group; [a]$p < .05$, [b]$p < .01$, [c]$p < .001$ compared with baseline.

54 years or older at 6 and 12 months and children aged 3 to 6 years at 6 months.

World Health Organization (WHO) criteria were used to define anemia: < 110 g/L hemoglobin for children aged 3 to 6 years, < 120 g/L hemoglobin for children aged 7 to 12 years, < 130 g/L hemoglobin for males aged 13 years or more, and < 120 g/L hemoglobin for females aged 13 years or more. There were no differences between the prevalence rates in the fortified and control groups at baseline. The consumption of fortified soy sauce led to a significant decrease in the prevalence of anemia, which was evident after six months (**table 3**). There was a further reduction in the prevalence of anemia at 12 months. The improvement was greatest in males aged 3 to 6 years and 7 to 18 years and in females aged 3 to 6 and 19 to 30 years.

TABLE 3. Changes in anemia prevalence (%) during the trial

Males

Group	Time of measurement	Age 3–6 yr	7–18 yr	19–54 yr	55+ yr
Fortified	Baseline	50.0	57.2	36.8	63.6
	6 mo	14.9^{c}	16.9^{c***}	9.8^{c*}	33.7^{b}
	12 mo	6.5^{c**}	15.7^{c**}	7.7^{c*}	21.1^{c}
	18 mo	18.1^{c*}	20.9^{c**}	11.2^{c*}	25.8^{b}
Control	Baseline	33.0	53.6	27.8	59.3
	6 mo	19.4	33.7^{c}	20.0	51.4
	12 mo	34.4	29.0^{c}	15.8^{b}	39.1
	18 mo	42.9	33.9^{c}	20.6	46.2

Females

Group	Time of measurement	Age 3–6 yr	7–18 yr	19–30 yr	31–54 yr	55+ yr
Fortified	Baseline	51.7	56.3	61.8	61.2	63.0
	6 mo	12.7^{c}	22.9^{c**}	16.4^{c*}	25.6^{c**}	28.7^{b}
	12 mo	10.7^{c}	12.1^{c***}	9.6^{c**}	17.1^{c*}	20.7^{c*}
	18 mo	25.6^{a}	15.7^{c***}	16.9^{c**}	18.4^{c***}	28.1^{b}
Control	Baseline	29.9	58.6	51.0	50.4	66.3
	6 mo	16.3	39.2^{b}	34.1	39.8	46.5
	12 mo	23.9	31.2^{c}	32.4^{a}	26.9^{c}	41.6
	18 mo	41.1	34.5^{c}	43.4	38.3^{b}	47.8

* $p < .05$, ** $p < .01$, *** $p < .001$ compared with control group; $^{a}p < .05$, $^{b}p < .01$, $^{c}p < .001$ compared with baseline.

A variable, but considerably smaller, decrease in the prevalence of anemia was also observed in most of the control subgroups. The prevalence rates were significantly lower in the fortified group than in the control group at all times, with the exception of children 3 to 6 years old at 6 and 12 months and men over 54 years old at 6 and 12 months.

Plasma ferritin

After log transformation, the data show that after one year of intervention, the plasma ferritin level of the fortified group increased significantly in all age and sex subgroups as compared with baseline levels ($p < .05$) (**table 4**). Both men and women in the older age group who received the unfortified soy sauce had higher ferritin values than the respective fortified groups. No specific reasons were found for this discrepancy.

Plasma retinol

By using a value of < 30 μg/dL as the cutoff point for subclinical vitamin A deficiency and < 20 μg/dL for clinical vitamin A deficiency, a large proportion of subjects could be diagnosed as having vitamin A deficiency, especially in the 7- to 18-year-old subgroup (**table 5**). There were no significant systematic differences in plasma retinol levels between the fortified and control subjects in any of the age and sex subgroups. There was an overall moderate improvement in plasma retinol levels in both groups after one year of intervention. The reasons for this change are not clear. No results are available for three- to six-year-old children, who would have been at high risk for nutritional vitamin A deficiency, because venous blood was not drawn in this age subgroup.

Discussion

NaFeEDTA fortification of soy sauce at a concentration of 29.6 mg of iron per 100 ml in a population that had an average consumption of 16.4 ml of soy sauce per person per day was very effective in increasing hemoglobin levels and reducing the prevalence of anemia in all age and sex subgroups in this trial. It also led to an improvement in iron status, as indicated by an increase in serum ferritin levels. The dietary iron content was relatively high in this population. The mean daily intakes for adults were between 22.1 and 27.5 mg. The average increase in iron consumption as a result of the use of NaFeEDTA-fortified soy sauce was only 4.9 mg of iron per person per day, equivalent to 18% and 22% of the dietary iron intake. The most plausible explana-

TABLE 4. Mean ± SD (no. of subjects) changes in plasma ferritin levels (μg/L) during the trial[a]

Males				
Group	Time of measurement	Age		
		7–18 yr	19–54 yr	55+ yr
Fortified	Baseline	4.31 ± 1.99 (446)	6.20 ± 2.28 (459)	5.53 ± 2.79 (73)
	1 yr	6.18 ± 2.05[c]** (352)	12.99 ± 2.12[c]*** (368)	8.44 ± 2.55[a] (64)
Control	Baseline	4.66 ± 2.00 (446)	6.64 ± 2.03 (415)	6.31 ± 1.87 (71)
	1 yr	5.05 ± 2.55 (389)	9.55 ± 2.70[c] (373)	9.51 ± 2.51[b] (62)

Females					
Group	Time of measurement	Age			
		7–18 yr	19–30 yr	31–54 yr	55+ yr
Fortified	Baseline	3.93 ± 2.08 (370)	3.11 ± 2.29 (157)	3.18 ± 2.37 (393)	5.03 ± 2.39 (91)
	1 yr	5.67 ± 2.22[c]* (284)	4.45 ± 2.96[b] (118)	5.04 ± 2.51[c] (349)	8.46 ± 2.60[c] (73)
Control	Baseline	4.11 ± 1.95 (335)	3.08 ± 2.45 (136)	3.82 ± 2.12 (395)	5.50 ± 2.13 (73)
	1 yr	4.74 ± 2.66[b] (301)	3.59 ± 3.05 (127)	4.52 ± 2.78[a] (392)	8.97 ± 2. 53[b] (65)

a. Serum ferritin levels were first calculated by log transformation, and then the mean value was subject to antilog transformation.
* $p < .05$, ** $p < .01$, *** $p < .001$ compared with control group; [a]$p < .05$, [b]$p < .01$, [c]$p < .001$ compared with baseline.

tion for such a significant impact from this relatively small amount of iron is the putative effect of EDTA on nonheme iron bioavailability. The diet consisted primarily of plant foods. The iron could therefore be presumed to be poorly bioavailable. NaFeEDTA is known to be absorbed satisfactorily from such diets [13]. Moreover, the EDTA iron enters the common dietary nonheme iron pool and promotes the absorption of the insoluble dietary iron as well [13,14].

Food is fortified with iron in other countries. The iron level has usually been higher than that used in this trial. In the United States and Canada, wheat flour is enriched with about 40 mg of iron per kilogram. If the per capita flour consumption is 200 g/day, the intake of added iron would be about 8 mg/day [15]. However, the fortification iron has usually been added in the form of an elemental iron powder. The bioavailability of these powders may be inadequate [16].

Moreover, absorption might well be reduced by the low bioavailability of iron in the Chinese diet. We suspect that the use of elemental iron powders would not be efficacious, but a study that is specifically designed to answer this question could have very important practical implications.

The effect of NaFeEDTA-fortified soy sauce on iron-deficiency anemia was found to be significant within six months and continued throughout the whole trial. This is in agreement with the model developed by Hallberg and coworkers [17], which predicted that 80% of the final adjustment in iron stores that occurs after a change in the dietary intake of available iron takes place in the first year.

We suggest that our study demonstrates the importance of bioavailability in ensuring the effectiveness of food fortification with iron. Further research is needed to provide direct evidence for this assertion. If confirmed, it might suggest that NaFeEDTA could be a preferable iron fortificant, the use of which should be promoted in areas where the diet consists primarily of plant food staples that are likely to have high levels of the most powerful inhibitors of iron absorption, such as phytates and polyphenols.

It is important to note that fortification was very effective in three- to six-year-old preschool children, as indicated by the 80% reduction in the prevalence of anemia. Although there were no significant differences between the fortified and control groups in the prevalence rates of anemia among three- to five-year-old girls, the fortified group had significant reduction of prevalence rates at 6, 12, and 18 months, whereas

TABLE 5. Mean ± SD (no. of subjects) changes in plasma retinol (vitamin A) levels (μg/dL) during the trial

Males				
Group	Time of measurement	Age		
		7–18 yr	19–54 yr	55+ yr
Active	Baseline	18.9 ± 8.3 (238)	34.8 ± 13.2*** (257)	31.3 ± 13.6 (38)
	1 yr	22.5 ± 8.5** (177)	40.9 ± 16.2 (156)	42.2 ± 19.9 (26)
Control	Baseline	20.2 ± 8.6 (279)	40.2 ± 15.5 (220)	35.8 ± 12.6 (47)
	1 yr	25.4 ± 10.7 (223)	41.5 ± 12.5 (152)	40.7 ± 12.1 (38)

Females					
Group	Time of measurement	Age			
		7–18 yr	19–30 yr	31–54 yr	55+ yr
Active	Baseline	20.6 ± 8.2 (201)	26.0 ± 8.5 (89)	27.6 ± 10.1 (220)	27.9 ± 10.7 (50)
	1 yr	24.3 ± 8.6* (154)	29.7 ± 10.6 (55)	31.2 ± 9.9 (162)	32.8 ± 12.5 (35)
Control	Baseline	20.5 ± 8.5 (183)	27.7 ± 11.2 (72)	28.6 ± 9.9 (217)	31.5 ± 12.7 (49)
	1 yr	26.6 ± 11.1 (143)	31.1 ± 10.1 (57)	33.1 ± 11.6 (184)	33.9 ± 11.0 (37)

* $p < .05$, ** $p < .01$, *** $p < .001$ compared with control group.

the control group had much less reduction at 6 and 12 months and even some increase at 18 months. The latter observation is very significant, because this age subgroup is one of the high-risk groups in China. It also relieves us of our concern that young children would not consume enough soy sauce for it to be an adequate vehicle for the delivery of iron. It is clear that fortified soy sauce is effective, at least in poor rural areas, in young children who consume adult foods. Individual estimates of soy sauce consumption are not available in this study. It is therefore not possible to estimate the minimum effective dose of iron-fortified soy sauce.

Another important observation is the persistence of anemia in a significant proportion of men and women who were 55 years of age or older. The baseline prevalence of anemia was very high in this subgroup (around 60%). At the end of the trial, the prevalence remained at about 30%. The etiology of this anemia was not established in our study. Other nutritional deficiencies, such as folate and vitamin B_{12} deficiency, should be considered in future studies.

The response to iron fortification that we observed demonstrates that iron deficiency is a major cause of anemia in the Haizijie Region. In most persons, the anemia was mild.

In most cases, hemoglobin levels were 0 to 15 g/L below their corresponding cutoff points; hemoglobin levels were below 90 g/L in only 27 cases (0.6%). Falciparum malaria does not occur in Guizhou Province, and hookworm infections are uncommon. Analysis of stool samples from 4,056 persons in the study villages performed at the beginning of the trial showed a prevalence of only 2%.

Although there were no significant differences in plasma retinol levels between the fortified and control groups, the data suggest that there may be a high prevalence of subclinical vitamin A deficiency in these villages. A more detailed evaluation that would include the younger children should be considered.

The data from this study do not allow us to make an adequate assessment of the iron status of the study population, because only plasma ferritin was measured. From the point of view of the assessment of effectiveness, we conclude that the provision of NaFeEDTA-fortified soy sauce improved the iron status of the study population, because plasma ferritin levels increased significantly after one year of intervention, and in most age and sex subgroups, the ferritin level in the fortified group was significantly higher than that in the control group. However, it also should be noted that the absolute ferritin levels in the fortified group after one year of intervention were still not adequate. Whether this is because the intervention period was not long enough or because the amount of iron was not sufficient should be clarified in further studies.

In conclusion, it is important to point out that the cost of NaFeEDTA fortification is low, although it is more expensive than elemental iron and several other iron compounds. Based on the results of our trial, the estimated annual cost of an effective intervention with NaFeEDTA-fortified soy sauce would be only US$0.007 per person. Very little additional equipment is needed to produce the fortified soy sauce, because the technology is simple. The use of fortified soy sauce is a potentially sustainable strategy for the control of iron deficiency and iron-deficiency anemia in China and other countries in which soy sauce is a commonly consumed condiment.

Acknowledgment

This study was supported by The Micronutrient Initiative, Ottawa, Canada.

References

1. MacPhail AP, Bothwell TH. The prevalence and causes of nutritional iron deficiency anemia. In: Fomon SJ, Zlotkin S, eds. Nutritional anemia. Nestle Nutrition Workshop Series 30:1–12. New York: Raven Press, 1992.
2. Ge KY, Zhai FY, Yan HC, Cheng L, Wang Q, Jia FM. The dietary and nutritional status of Chinese populations in 1990s. Acta Nutrimenta Sinica 1995;17:123–34.
3. Fu ZY, Jia FM, He W, Fu G, Chen CM. The status of anemia in children under 5 and mothers in China and its factor analysis. Acta Nutrimenta Sinica 2003;25:70–3.
4. Sun JQ, Wang HQ, Shen L, Li JY, Gu WX, Han XL, Guo CL, Zhou YJ. Anemia prevalence of Shanghai children and adolescents in 2002 and the related factors. Shanghai J Microelements 2003;1:9–12.
5. Ross J, Chen CM, He W, Fu G, Wang YY, Fu ZY, Chen MX. Effects of malnutrition on economic productivity in China as estimated by PROFILES. Biomed Environ Sci 2003;16:195–205.
6. Huo JS, Piao JH, Miao H, Yang XG, Chen JS. Study on iron absorption of NaFeEDTA in human subjects. Acta Nutrimenta Sinica 2001;23:126–9.
7. Yu B, Huo JS, Huang J, Sun J, Li WX. The effects of NaFeEDTA on the organoleptic and physico-chemical properties of soy sauce. J Hyg Res 2003;32(suppl):50–3.
8. Huo JS, Sun J, Miao H, Yu B, Yang T, Liu ZP, Lu CQ, Chen JS, Zhang D, MaYZ, Wang AX, Li YL. Therapeutic effects of NaFeEDTA-fortified soy sauce in anaemic children in China. Asia Pac J Clin Nutr 2002;11:123–7.
9. Compendium of Food Additive Specifications. FAO Food and Nutrition Paper, No. 52, Addendum 2, 1993. Rome: Food and Agriculture Organization.
10. Wang GY. The Chinese food composition table. Beijing: People's Medical Publishing House, 1992.
11. Wang G, Ye XM, Chen JS. Detecting retinol and vitamin E in human serum samples with HPLC. Acta Nutrimenta Sinica 1988;10:272–9.
12. Ge KY, Zhai FY, Yan HC. The dietary and nutritional status of Chinese Population (1992 National Nutrition Survey). Beijing: People's Medical Publishing House, 1996:442–6.
13. International Nutritional Anemia Consultative Group (INACG). Iron EDTA for food fortification. Washington, D.C.: Nutrition Foundation, 1993.
14. MacPhail AP, Patel RC, Bothwell TH, Lamparelli RD. EDTA and the absorption of iron from food. Am J Clin Nutr 1994;59:644–8.
15. Cao JS, Wang XQ. Nutrient fortificants for foods. Beijing: Chinese Light Industry Publishing House, 2002:210–4.
16. Hurrell R, Bothwell T, Cook JD, Dary O, Davidsson L, Fairweather-Tait S, Hallberg L, Lynch S, Rosado J, Walter T, Whittaker P; SUSTAIN Task Force. The usefulness of elemental iron for cereal flour fortification: a SUSTAIN Task Force report. Sharing Science & Technology to Aid in the Improvement of Nutrition. Nutr Rev 2002;60:391–406.
17. Hallberg L, Hulten L, Gramatkovski E. Iron absorption from the whole diet in men: How effective is the regulation of iron absorption? Am J Clin Nutr 1997;66:347–56.
18. Chinese Nutrition Society. Chinese DRIs. Beijing: Chinese Light Industry Publishing House, 2000.

Commentary on "Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: A population-based intervention trial"

To address micronutrient deficiencies affecting large population groups, food fortification is the most cost-effective intervention and reaches a higher proportion of the population at risk than any other feasible intervention. Successful examples include the addition of a relatively inexpensive and highly effective iodine compound to salt for human consumption in countries where iodine deficiency is common. Preventing iodine deficiency is important because, if present during pregnancy, the future cognitive performance of offspring can be negatively affected. A meta-analysis of 18 studies showed an IQ lower by more than 13.5 points in children in iodine-deficient populations compared with non-iodine deficient populations [1].

Fortification of cereal flours with folic acid has been another success. In the United States [2] and Canada [3], the addition of folic acid to wheat flour resulted in a rise in blood levels of folate and a corresponding decrease in congenital neural-tube defects.* Folate is now being added to micronutrient fortificant premixes for flour fortification in more than 60 countries. Originally used in Guatemala [4], and now in many other countries, the fortification of sugar with vitamin A has been implemented successfully on a national scale.

Iron deficiency affects a quarter of the world's population and is widespread in most developing country populations. It has serious effects on immunity, morbidity from infections, physical work capacity, and cognition. In many industrialized countries and a growing number of developing nations, the fortification of wheat or maize flour with a premix that includes iron is an approach that reaches most of the population. Reports on the benefits for iron status after introducing flour fortification in Venezuela have been published [5, 6].

There are, however, constraints on food fortification. A first factor in the effectiveness of a fortified food is whether it is widely consumed by the populations targeted. A second factor is the fortified food's acceptability and accessibility to the targeted population. A third is its effectiveness in delivering the added micronutrients into the human system, i.e., the bioavailability of the added nutrients.

The paper by Chen et al. in this issue of the *Bulletin* [7] is important for several reasons. First, it demonstrates the efficacy of fortifying a condiment with NaFeEDTA, a specific iron compound that has been receiving increased attention as a major food fortification component in recent years. Earlier research in the People's Republic of China (PRC) determined that NaFeEDTA was the most desirable form of iron for use in a liquid preparation such as soy sauce for several reasons. Consumer and producer acceptance was based on the lack of detectable organoleptic differences when compared with the non-fortified product, and a longer shelf life than soy sauce fortified with $FeSO_4$ because NaFeEDTA does not precipitate during storage [7].

The price difference between the non-fortified product and the NaEDTA–fortified product was acceptable to consumers. Nutritionists were pleased that the iron from NaFeEDTA fortified soy sauce is well absorbed [7], and regulators are satisfied with the safety of NaFeEDTA based on its listing by the Codex Alimentarius and its GRAS ("generally recognized as safe") rating in the United States.

Second, fortified soy sauce has developed out of the decision by China's nutrition specialists to develop fortified products that are widely consumed by major portions of the population in China and several other countries of Asia. In this region large populations depend on rice as their cereal staple, but despite some recent progress, rice itself has proven difficult to fortify with sufficient consumer acceptance, whatever the form of iron. The present study finds that for a rice-eating population in which soy sauce use is widespread, the fortified condiment can serve as

* Following statutory fortification of all enriched cereal grain products since January 1998 in the US, birth prevalence of neural-tube defects dropped from 37.8 per 100,000 live births before fortification to 30.5 per 100,000 live births conceived after mandatory folic acid fortification. In Canada, a higher level of folic acid fortification was the basis for a dramatic 48% decline in early mid-trimester prevalence of neural-tube defects.

an effective vehicle for providing additional iron.

This work to develop fortified soy sauce with NaFeEDTA in China has also contributed to successful efforts to fortify both soy sauce and fish sauce in Thailand [8] and fish sauce in Vietnam [9].

Third, at the time of this study NaFeEDTA had not yet been used in a large scale project for the prevention of iron deficiency. This successful use of fortified soy sauce has already encouraged its production and use in the fortification of cereals and other foods where its combined properties of relatively high absorption, stability, and longer shelf life are advantages that help offset its higher cost compared with $FeSO_4$ and elemental iron powders.

For example, the results of this efficacy study helped open the door for its use in the fortification of wheat in a large project in Western China with funding from GAIN (Global Alliance for Improved Nutrition). As a result, NaFeEDTA is now more widely recommended for use in fortifying high-extraction wheat and maize flours. Moreover, the production of food-grade NaFeEDTA is growing, and its price is decreasing. This study provides information that will serve to increase the appropriate and cost effective use of NaFeEDTA in the fortification of food products and to support staple food and condiment fortification.

The study by Chen et al. may also assist those working on developing new and more readily available fortified complementary foods for infants and young children. This is important because fortified complementary foods will prevent iron deficiency in children too young to consume significant amounts of fortified staple foods or condiments to meet the iron needs of their rapidly growing bodies and developing brains [10]. Even with exclusive breastfeeding, breast milk does not provide more than half of the iron required by the rapidly growing and developing infant. The remaining iron needed initially comes from the iron stores the infant has at birth. These stores are normally exhausted by about six months in offspring born at term of well-nourished mothers. For infants born of iron-deficient mothers, these stores may be exhausted by the age of four months, and in low birthweight infants, by two months of age.

The most effective means available in industrialized countries to reach infants with the additional iron they need, and increasingly those in urban and semi-urban areas of other countries, is the fortification of cereals for complementary feeding. Provision of iron supplements is another alternative, but carries with it serious logistic, cost, and compliance problems and, recently, concern about its safety for iron-replete children in areas where malaria is endemic.

A promising recent innovation is the development and introductory use of a variety of "in-home fortificants." These range from small packets of microencapsulated micronutrients that can be sprinkled on any complementary food to crushable multimicronutrient tablets and spreads containing micronutrients [11]. Among these, the "sprinkles," developed at SickKids Hospital in Toronto, the same research facility responsible for the first iron-fortified infant cereal, has moved the most quickly toward widespread production [12]. This product is now being used in several countries to provide micronutrients to infants and young children, and as part of the emergency relief effort in Indonesia following the December 2004 tsunami.

In summary, micronutrient fortification of any appropriate locally available food consumed by population groups at risk of micronutrient deficiencies should be encouraged. Identification of alternative vehicles for fortification where wheat flour is not widely consumed is important. The selection and development of fortified soy sauce for the large populations where rice is the dominant cereal staple is a step that has major significance for many populations in Asia.

Unfortunately, fortification of staple foods and condiments does not solve the problem of population groups with higher needs for some specific micronutrients such as iron during certain periods of life (infancy and pregnancy). The need for prevention of iodine, iron, and folate deficiencies among pregnant women, and iron and vitamin A deficiencies among young children, are among the most important indications for micronutrient programs. It is especially important to find ways to provide additional iron to infants from 6 to 24 months of age, including those who are breastfed, who cannot consume enough fortified flour or soy sauce to benefit sufficiently. NaFeEDTA iron is a fortificant that is growing in recognition and use in efforts to create more food products that can deliver biologically effective amounts of iron to large population groups.

Nevin S. Scrimshaw
Gary R. Gleason
International Nutrition Foundation
Boston, Mass., USA

References

1. Bleichrodt N, Born MP. An analysis of research on iodine and its relationship to cognitive development. In: The damaged brain of iodine deficiency. Stanbury J (Ed.). New York: Cognizant Communication Corporation, 1994:195–200.
2. Honein MA, Paulozzi LJ, Mathews TJ, Erickson JD, Wong LY. Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. JAMA 2001;285:2981–6.
3. Ray JG, Meier C, Vermeulen MJ, Boss S, Wyatt PR, Cole DE. Association of neural tube defects and folic acid food fortification in Canada. Lancet 2002;360:2047–8.
4. Arroyave G. Fortification of sugar with vitamin A: Bases, implementation and evaluation. In: Nutrition in the community. Maclean DS, ed., London: John Wiley & Sons, 1983.
5. Layrisse M, Garcia-Casal MN, Mendez-Castellano H, Jimenez M, Olavarria H, Chavez JF, Gonzalez E. Impact of fortification of flours with iron to reduce the prevalence of anemia and iron deficiency among schoolchildren in Caracus, Venezuela: A follow-up. Food Nutr Bull 2002; 23:384–389.
6. Layrisse M., Chavez JF, Mendez-Castellano H, Bosch V, Tropper E, Bastardo B, Gonzalez E. Early response to the effect of iron fortification in the Venezuelan population. Am J Clin Nutr 1996; 64:903–7.
7. Chen J, Zhao X, Zhang X, Yin S, Piao J, Huo J, Yu B, Qu N, Lu Q, Wang S, Chen C. Studies on the effectiveness of NaFeEDTA-fortified soy sauce in controlling iron deficiency: A population-based intervention trial. Food Nutr Bull 2005;26:177–86.
8. Chavasit V, Nopburabutr P, Kongkachuichai R. Combating iodine and iron deficiencies through the double fortification of fish sauce, mixed fish sauce, and salt brine. Food Nutr Bull 2003;24:200–7.
9. Thuy PV, Berger J, Davidsson L, Khan NC, Lam NT, Cook JD, Hurrell RF, Khoi HH. Regular consumption of NaFeEDTA-fortified fish sauce improves iron status and reduces the prevalence of anemia in anemic Vietnamese women. National Institute of Nutrition, Hanoi, Vietnam. Am J Clin Nutr 2003 Aug;78(2):284–90.
10. Fidler MC, Davidsson L, Walczyk T, Hurrell RF. Iron absorption from fish sauce and soy sauce fortified with sodium iron EDTA. Am J Clin Nutr 2003; 78(2):274–8.
11. Lock G. The foodLET vehicle designed for and used in the IRIS I intervention. Food Nutr Bull 2003; 24(Suppl): S16–9.
12. Zlotkin SH, Arthur P, Yeboah-Antwi K, Yeung GS. Efficacy of microencapsulated ferrous fumarate ‘sprinkles’ to treat anemia in infants and children. 2003. FASEB Experimental Biology Conference, San Diego, Calif, USA.

Chile's national nutritional supplementation program for older people: Lessons learned

Alan D. Dangour, Ximena Moreno, Cecilia Albala, Alberto Rivera-Marquez, Lydia Lera, Alicia Villalobos, Saul S. Morris, and Ricardo Uauy

Abstract

Demographic changes in developing countries have resulted in rapid increases in the size of the older population. As a result, health-care budgets face increasing costs associated with the declining health and function of older people. Some governments have responded to this situation by designing innovative programs aimed at older people. One such program, implemented by the government of Chile, distributes an instant food mix fortified with vitamins and minerals to all persons over 70 years old who are registered by the national health service. The national health service covers approximately 90% of the older population. The program specifically targets nutritional vulnerability and micronutrient deficiency, which are common among poor older people in Chile. We present here the findings of a one-year investigation into all aspects of Chile's program for the elderly. The research included in-depth interviews with policy makers and program implementers, focus group discussions with user groups, analysis of the micronutrient content of the nutritional supplement, and telephone interviews of a random sample of older people. The results demonstrate that there can be a considerable degree of self-targeting within national programs; programs need to be sufficiently flexible to permit periodic protocol change; user groups must be consulted both before and during program implementation; and the design of an effective program evaluation must be in place before program implementation. It is hoped that these results will be useful to policy makers and implementers planning programs aimed at improving the health and function of older people.

Alan D. Dangour, Alberto Rivera-Marquez, Saul S. Morris, and Ricardo Uauy are affiliated with the Nutrition and Public Health Intervention Research Unit, Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London. Ximena Moreno, Cecilia Albala, Lydia Lera, and Ricardo Uauy are affiliated with the Public Nutrition Department, Institute of Nutrition and Food Technology (INTA), University of Chile, Santiago, Chile. Alicia Villalobos is affiliated with the Programa del Adulto Mayor, Ministry of Health, Santiago, Chile.

Please address queries to the corresponding author: Dr. Alan Dangour, Nutrition and Public Health Intervention Research Unit, Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK; e-mail: Alan.Dangour@lshtm.ac.uk.

Mention of the name of firms and commercial products does not imply endorsement by the United Nations University.

Key words: Nutritional supplementation, older people, program effectiveness

Introduction

Across Latin America, declining infant and child mortality rates, combined with improved access to health care, are increasing the mean life expectancy, resulting in a progressive increase in the proportion of older people in the population. In the year 2000, nearly 8% of the total population of Chile was over 65 years of age, as were 11% and 13%, respectively, of the populations of neighboring Argentina and Uruguay [1]. These changes have brought into sharp focus the difficulties in sustaining many of the region's state pension schemes, which are the main source of income for older people in all of the countries of the Southern Cone of Latin America [2].

The economic difficulties that many Latin American countries experienced in the 1990s have only heightened the urgency of the quest for an adequate social safety net for the older poor. Although older people are not overrepresented among the lowest-income quintile of Latin American countries [2], poverty is estimated to affect up to one-quarter of persons over 65 years of age in Chile and around one-third in Colombia and El Salvador (personal communication, Quentin Wodon, World Bank). In contrast to those of industrialized countries, most populations in Latin American countries are aging without the corresponding economic development necessary to secure health and social services for the aged. There are strong associations between poverty and food insecurity in this age group, and it has been demonstrated that even in the relatively wealthy United States, food insecurity among older people is associated with poorer dietary intake, lower nutritional status, and poorer self-reported health status [3, 4].

Various program options exist for tackling the twin problems of food and nutrition insecurity among older people. Food baskets are still popular in some parts of Latin America, and community kitchens have also been experimented with, particularly in Argentina. In Mexico City, the local government is providing a universal monetary pension transferred electronically to a plastic debit card that can be used in supermarkets. None of these options, however, address the particular problems facing older people who, for a variety of physiological, psychological, economic, and social reasons, may struggle to attain not just macronutrient but also micronutrient sufficiency in their diets [5–7]. Adequate micronutrient intake in older people is increasingly seen as essential for the maintenance of health and function into later life [8, 9].

In this article, we describe and assess an innovative food-based program implemented by the Ministry of Health in Chile, which specifically addresses the issue of micronutrient sufficiency in the diet of older people. We begin by outlining the main characteristics of the program as originally designed. We then present information on program uptake and compliance and, drawing on material from a series of focus group discussions, summarize the views of older people about the program. Finally, we present some "lessons learned" that we believe have relevance to other, similar programs worldwide.

Program description

The Health Program for the Older Person in Chile [10] encompasses a number of actions in health promotion, disease prevention, and curative care, promotes successful aging, and is linked to public programs addressing equity and poverty alleviation in older people. A core component of this initiative is the Program for Complementary Food in Older People (Programa de Alimentación Complementaria para el Adulto Mayor, PACAM) [11]. The program is officially defined as a group of actions in nutrition whose purpose is to contribute to improvements in the health and quality of life of older people. To be eligible for the program, persons must be registered at their local health center and be at least 70 years of age.

The primary component of the PACAM is a powdered food called *Años Dorados* (golden years) that is composed of a cereal and legume mix fortified with vitamins and minerals. Every beneficiary is entitled to collect two 1-kg sachets of *Años Dorados* per month from collection points located in rural health posts, health centers, and hospitals. This dietary supplement is designed to provide approximately 20% of the daily energy requirements and 50% of the daily micronutrient requirements when consumed in the recommended quantity of 50 g per day. Other elements of the PACAM are monthly nutritional status assessments and nutritional and health counseling. Older people cannot become beneficiaries of the PACAM unless they also comply with periodic medical surveillance. The main characteristics of the PACAM are presented in **box 1**.

The PACAM was started as a pilot initiative in 1998 in the metropolitan region of Santiago. After positive

BOX 1. Main characteristics of Chile's Program for Complementary Food in Older People (PACAM)

Benefit	Two 1-kg sachets of *Años Dorados* collected from health centers on a monthly basis Four flavors available: lentils, peas, asparagus, and mixed vegetables
Use of the benefit	*Años Dorados* is designed to be used to prepare an instant soup (with water or milk) or as a flour substitute in a range of foods A recipe book is available for beneficiaries
Eligibility	Registered with national health service Persons aged 70+ nationwide Persons aged 65+ undergoing antituberculosis treatment nationwide Persons aged 65+ living in homes for destitute people nationwide
Budget (2003)	Chilean $30,500 million (US$51 million)[a] Chilean $1,500 (US$2.5)[a] for 1 kg of *Años Dorados*
Partnership	Ministry of Health Private food manufacturers participate in public bidding processes every 6 months for the contract to make *Años Dorados* National Supply Center for storage and distribution
Other characteristics	Nutritional status assessment and counseling Links to health program for older people

a. Exchange rate as of March 2004 (600 Chilean pesos = US$1) evaluation of sensory characteristics (taste and smell) and acceptability in laboratory and field settings, it was extended in 2001 to cover the entire country [12–14]. *Años Dorados* is distributed throughout the country by the comprehensive primary health network set up for the distribution of milk powder to children, a longstanding national program established in 1945. However, health authorities acknowledge that the current takeup rate of *Años Dorados* is variable, due in part to problems associated with the distribution of the product and the fact that older people have only recently become the focus of public health action.

In an effort to highlight the value of the product, the Chilean Government requires the sale of *Años Dorados* in supermarkets. This enables those who would like more than their entitlement or who are not currently eligible for the benefit to purchase the product. It is hoped that this will also have the effect of demonstrating the value of the product to current beneficiaries, thereby increasing its status in both monetary and sociological terms.

TABLE 1. Nutritional composition of the *Años Dorados* food supplement used in the Program for Complementary Food in Older People (PACAM), Chile, 2004[a]

Nutrient	Per 100 g	Per serving
Energy (kcal)	400	200
Protein (g)	13	6.5
Saturated fat (g)	1.6	0.8
Monounsaturated fat (g)	5.4	2.7
Polyunsaturated fat (g)	4	2
Cholesterol (g)	0	0
Carbohydrates (g)	62.3	31.2
Total fiber (g)	6.2	3.1
Vitamins and minerals		
Vitamin A (μg RE)	240	120
Vitamin C (mg)	30	15
Vitamin D (μg)	1.5	0.75
Vitamin E (mg TE)	4	2
Thiamine (mg)	0.4	0.2
Riboflavin (mg)	0.4	0.2
Niacin (mg NE)	4.5	2.25
Pyridoxine (mg)	1	0.5
Folate (μg)	100	50
Vitamin B_{12} (μg)	0.5	0.25
Sodium (mg)	280	140
Calcium (mg)	400	200
Iron (mg)	2.8	1.4
Phosphorus (mg)	400	200
Magnesium (mg)	150	75
Zinc (mg)	3	1.5

a. RE, retinol equivalents; TE, tocopherol equivalents; NE, niacin equivalents.

Table 1 shows the nutritional composition of *Años Dorados* per 100 g of dry material, as required by the Ministry of Health in the Guidelines for the Nutrition of Older People in Chile [9] and used in the technical specifications of the bidding process. As part of the evaluation of the program, a detailed compositional analysis of the key micronutrients in *Años Dorados* (vitamin A, vitamin C, vitamin D_3, α-tocopherol, thiamine, riboflavin, pyridoxine, niacin, folate, and vitamin B_{12}) was conducted on samples obtained from distribution points in health centers. Duplicate samples of the nutritional product, as supplied by the three main private manufacturers, were analyzed in a blinded manner by an internationally recognized independent laboratory familiar with such analyses (Roche Laboratories Analytical Services, Basel, Switzerland). The analyses demonstrated that the supplement provided by two of the three manufacturers did not attain the required content (within a margin of ±20%) of vitamin E, niacin, and vitamin B_{12}. The most significant departure from the specified norms was in vitamin B_{12} content.

In discussions with manufacturers, it was determined that the addition of vitamin B_{12} was carried out on a dry basis, that is, by adding the crystalline vitamin to the powdered product. Given the very low vitamin B_{12} content of the product (5 μg/kg), it is virtually impossible to assure homogeneity, and therefore some bags could contain an excess of vitamin B_{12} while most contained virtually nothing. The information obtained from this analysis has resulted in several changes in the norms and technical specifications established by the Ministry of Health of Chile. Specifically, the technical specifications indicating the process by which some micronutrients should be added in the manufacturing process have been modified, and both the analytic monitoring of nutrient composition of the product by manufacturers and the quality control conducted by the Ministry of Health have been considerably enhanced.

Uptake of *Años Dorados* and the nature of program users

In order to assess the current level of participation in the PACAM by the target population, a standardized telephone survey was conducted in August 2003. The individuals contacted in the survey were members of a cohort involved in a large, cross-sectional study conducted in Santiago, Chile, between October 1999 and March 2000. This study, called SABE (Health, Well-being, and Aging in Spanish) was part of a multicenter project aiming to evaluate the health conditions of older people in Latin America and the Caribbean [15]. The SABE sample included 958 randomly selected persons aged 70 years or older living in Santiago. In

August 2003, research nurses made a maximum of four attempts to contact each of these individuals by telephone and were able to contact a total of 393 persons aged 70 years or more, 67% of whom were female. This represents 41% of those aged 70 years or more from the original SABE cohort. Of the remaining SABE sample, 2 (0.4%) were institutionalized and 103 (18%) had died. A total of 460 (48%) of the original SABE cohort were lost to follow-up: 92 (20%) withdrew during the SABE study, 147 (32%) had no telephone at baseline and were thus unable to be contacted by the research nurses, and 221 (48%) could not be contacted. The research was approved by the research ethics committees of the Institute of Nutrition and Food Technology (INTA) and the London School of Hygiene and Tropical Medicine (LSHTM).

To assess the representativeness of the follow-up sample, the baseline characteristics of persons in the sample were compared with those of persons aged 70 years or more who were in the SABE survey but were not contacted in the current study (n = 565). There were no differences between the two groups in mean age, proportion of women, or socioeconomic level of the area of residence. However, because the follow-up survey was carried out by telephone, the follow-up sample was found to be significantly richer, as measured by ownership of a range of household goods, and also significantly better educated (p = .01) than the individuals from the SABE cohort who were not in the follow-up sample. There were no baseline differences between the two groups in scales of physical function (such as activities of daily living), depression, or health status (prevalence of diabetes, hypertension, and osteoarthritis).

Those persons who were contacted were informed of the nature of the study and gave oral consent to answering an 18-item questionnaire regarding their knowledge and level of involvement with the PACAM. The individuals in the follow-up sample reported that they were predominantly ambulatory (95%, 374/393), and the majority (60%, 235/393) reported either excellent, very good, or good health, with only 3% (10/393) reporting "poor" health. The sample was drawn from across the socioeconomic spectrum, with 10% (41/393) living in areas of higher socioeconomic status and 18% (71/393) living in poorer areas.

During telephone interviews, 67% (262/389) of the persons in the follow-up sample reported that they were registered at the local health center and thereby eligible to be enrolled in the PACAM; 52% (195/377; the denominator is different from the preceding because not all participants provided responses to every item of the telephone-administered questionnaire) knew about the availability of Años Dorados; and 30% (118/387) reported that they were current consumers of the nutritional supplement. Among those registered at health centers, 70% (184/262) were enrolled in the PACAM, and 44% (116/262) reported currently consuming Años Dorados. Finally, among those who were registered in the health center and knew of the availability of Años Dorados, 66% (114/173) reported that they consumed it.

Among those reporting that they did not currently consume Años Dorados, 36% (97/269) said that they were not registered at the health center and were therefore not eligible to receive the supplement. However, there was also a range of other reasons for nonconsumption: 32% (87/269) reported that they did not know about the program, 8% (22/269) that they did not need the supplement, 8% (22/269) that they did not like the supplement, and 3% (7/269) that they were not able to go to the health post to collect the supplement. The views of older people about the program were collected in a series of focus group discussions conducted by one of the authors, a psychologist (X.M.). A summary of their views is presented in **box 2**.

Persons living in poorer *comunas* (state-defined geographic urban areas whose socioeconomic status is defined by the Ministry of Planning [16]) were significantly more likely than those living in richer *comunas* to be registered at a health center (test for trend χ^2 = 15.6, p < .001) (**fig. 1**). Persons living in poorer *comunas* were also significantly more likely than those living in richer areas to know about the availability of the nutritional supplement (test for trend χ^2 = 7.6, p = .02). Finally, there was a significant decrease in self-reported consumption of *Años Dorados* with increased socioeconomic status of the *comuna* (test for trend χ^2 = 6.3, p = .04). There was only one gender difference present in these findings: in *comunas* of medium socioeconomic status, women were significantly more likely than men to be aware of the program (59% vs. 42%; Pearson's χ^2 test = 7.4, p = .006).

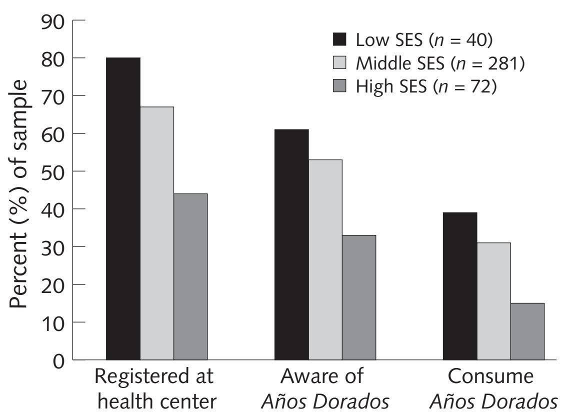

FIG. 1. Percentages of sample registered in health center, aware of availability of Años Dorados, and reporting the consumption of *Años Dorados*, according to socioeconomic status of *comuna* of residence in 2003 in Santiago, Chile. SES, socioeconomic status

Among those reporting current consumption of the supplement, 89% (101/113) reported collecting *Años Dorados* every month from the health center, and 93% (104/112) stated that the amount they received was sufficient for the month. However, less than half of the sample (46%, 51/110) reported that they consumed all of the supplement themselves; 37% shared it with one other person (41/110) and 16% with three to five other people (18/110). In general, the supplement was very well received, with 59% (60/102) reporting daily consumption, and among those who had ever tasted the supplement, 86% (163/189) stated that it tasted good or very good.

The SABE study (from which the current sample were drawn) collected information on health and function in older people. These data, collected approximately five years before the current follow-up survey and before the introduction of the PACAM, were used to compare persons who reported current consumption of *Años Dorados* with those who did not. Persons reporting current consumption of *Años Dorados* were significantly less likely to have reported five years previously that they had completed secondary school (comparison of proportions $\chi^2 = 19.9$, $p < .001$) (**fig. 2**). There were no gender differences present in this relationship. Furthermore, analysis of markers of socioeconomic status demonstrated that those reporting current consumption of *Años Dorados* were poorer in terms of ownership of household goods five years before the current survey. Although they were as likely as nonconsumers to report ownership of refrigerators, washing machines, televisions, videos, radios, heaters, telephones, and fans,

BOX 2. Perceptions of the Program for Complementary Food in Older People (PACAM) among older people in Santiago

From August to October of 2003, seven focus group interviews were conducted with older people in the Greater Santiago Metropolitan Region using a structured format. Some of the approximately 80 older people interviewed were regular users of *Años Dorados*, while others were infrequent or nonusers; all were of relatively low socioeconomic status. A more in-depth qualitative assessment of the program was conducted in a small number of individuals. Some of the major points to emerge from these interviews are outlined below.

Factors affecting the initial uptake of *Años Dorados*

There were many complaints about the lack of available information about the program and the product. Some nonusers were unaware of how to get *Años Dorados*, and many users felt poorly informed about alternative preparation methods. Few had seen the official recipe book.

Among those who had not tried the product, many preconceptions about the presentation and quality were identified: "*A woman ate it and didn't like it*"; "*It had a mouse in it.*" Organized social groups seemed effective at reinforcing positive and negative images of the program.

There was a strong sense of *Años Dorados* as a medical intervention rather than a food: "*[At the health center] they give me aspirin and Enalapril. And soups also.*" For some nonusers, the association of the product with the health system and with illness in particular appeared to be off-putting.

The product tended to be seen as a welcome addition to limited household resources: "*Thank goodness they give us at least that. Something is better than nothing.*" On the other hand, it carried the stigma of a handout for the very poor: "*For people who don't have anything it's a favor [the government] does for them.*" It was common for nonusers to reject the program as inappropriate for persons of their social standing: "*We're poor, but not that poor.*" Such persons might collect the product from the health center and then pass it on to others they felt needed it more.

Factors affecting the continued use of *Años Dorados* over time

Among those who had tried the product, there were generally favorable assessments of the flavors and presentation: "*Nice, really nice. I find that the vegetable flavor is the best of all.*" There was also a widespread appreciation of the nutritional qualities of the product: "*It's got lots of vitamins, all kinds.*"

There was a sense that the distribution of the product was well organized and that some health centers made special efforts to give individuals the flavor that they preferred. However, it was rare for the full range of flavors to be available at any given time. Some respondents mentioned being bored with eating the same flavors regularly.

Only a few of those interviewed claimed to feel better as a result of eating *Años Dorados*. On the other hand, it was rare for respondents to say that the product had not agreed with them.

For some, eating *Años Dorados* appeared to be a necessary, and perhaps joyless, part of the struggle against physical deterioration: "*It's a routine you have to follow as part of taking care of yourself – just like not eating salt – if you want to live a bit longer.*"

Many of the older people described their lives in terms of a constant struggle to make ends meet: "*Many people don't realize the juggling act a pensioner has to pull off to be able to survive.*" For these people, the additional resource provided by *Años Dorados* was welcome.

Factors affecting the quantity of *Años Dorados* consumed

Some of those interviewed claimed not to share the product, whereas others said they did share it with neighbors or family: "*I give it to my grandchildren, who are 16 and 17 years old.*" One woman mentioned also giving it to her dog. In general, however, there was fierce censure of those identified as wasting an important resource.

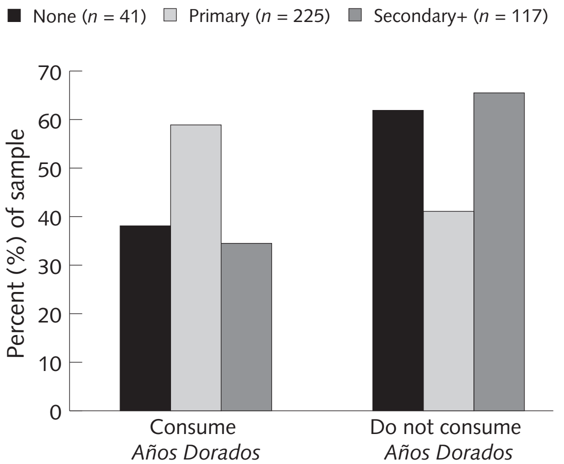

FIG. 2. Percentage of sample reporting consumption of *Años Dorados* in Santiago, Chile, in 2004, according to reported level of educational achievement in 1999-2000

they were less likely to report ownership of microwave cookers (28% vs. 40%, $p = .03$) and water heaters (77% vs. 85%, $p = .06$). Moreover, those reporting current consumption of *Años Dorados* were significantly less likely to have reported five years earlier that they had "enough to live on" (27% vs. 39, $p = .03$).

Anthropometric measurements obtained in the original SABE study were used to compare body size in those currently reporting and not reporting consumption of *Años Dorados*. **Table 2** shows that approximately five years prior to the current follow-up survey, men reporting current consumption of *Años Dorados* were slightly but not significantly shorter and lighter than those not reporting its current consumption. Similarly, women reporting current consumption of *Años Dorados* were slightly but not significantly shorter five years earlier than those not reporting its current consumption.

Although there were no differences between current consumers and nonconsumers in markers of physical or mental function measured five years earlier (data not shown), there were differences between current consumers and nonconsumers in some markers of health status. **Table 3** shows that those reporting consumption of *Años Dorados* were significantly less likely than those not consuming the supplement to have reported that their health was "good or better" five years earlier ($p = .002$). Similarly, current consumers reported a significantly higher prevalence of diabetes five years previously than did nonconsumers ($p = .01$). Supplement consumers were slightly less likely to have reported using the health services in the preceding three-month period ($p = .06$). Finally, current consumers were more likely than nonconsumers to have reported perceived weight loss five years earlier ($p = .009$).

TABLE 2. Comparison of measures of preprogram body size (data collected in Santiago, Chile, 1999–2000) between consumers and nonconsumers of *Años Dorados* as of 2003 (mean ± SD)

Measure	Consumers	Nonconsumers	*p* value
Men			
n	34	93	
Age (yr)	76.7 ± 4.6	76.6 ± 5.9	.9
Height (cm)	163.9 ± 6.4	165.6 ± 6.9	.2
Weight (kg)	71.0 ± 11.3	75.4 ± 12.0	.06
Body-mass index (kg/m^2)	26.5 ± 4.2	27.5 ± 3.8	.2
Women			
n	83	173	
Age (yr)	78.6 ± 6.2	78.6 ± 6.3	.9
Height (cm)	148.6 ± 5.8	150.2 ± 6.3	.06
Weight (kg)	63.9 ± 11.9	64.4 ± 11.5	.7
Body-mass index (kg/m^2)	28.9 ± 5.2	28.6 ± 4.9	.6

Conclusions and research recommendations

The PACAM is the newest component of the Chilean Complementary Nutrition Program. The program is designed to provide all Chileans at least 70 years of age with approximately 50% of their total daily micronutrient requirements and 20% of their total daily energy requirement. By using a fortified cereal and legume powdered food, the program manages to supply micronutrients at a cost that is considerably lower per unit weight than can be achieved by consuming more expensive regular foods. Furthermore, although the data presented in this paper certainly highlight possible areas for improvement of the program, they also suggest that current users are, on the whole, content. No information is available on changes in food security among eligible persons since the initiation of the program. However, the significantly greater consumption of the supplement by persons living in *comunas* of low socioeconomic status than by persons living in *comunas* of high socioeconomic status suggests that there is a greater requirement for such programs among poor persons, who may be food insecure.

In common with Chile's more longstanding programs, the PACAM integrates nutrition supplementation with health-care delivery and disease prevention. This is an important strength, since it secures access to health surveillance and care, including the management and control of common disease conditions, while it also provides a food supplement tailor-made for the target group. The program serves to attract older people to the health centers, since it includes all beneficiaries of the National Health Service. Although nearly 90% of all older people in Chile are eligible to be enrolled in the National Health Service and thereby entitled to the PACAM, the data presented in this paper suggest

TABLE 3. Comparison of markers of preprogram function and health (data collected in Santiago, Chile, 1999-2000) between consumers and nonconsumers of *Años Dorados* as of 2003 (percentage of respondents)

Marker	Consumers (n = 117)	Nonconsumers (n = 266)	p value
Self-reported health status			
Good or better	23.3	42.0	.002
Medical health status			
Prevalence of diabetes	18.8	9.8	.01
Prevalence of osteoarthritis	39.3	31.6	.1
Health service use			
Consultation in previous 3 mo	15.5	24.2	.06
Perceived weight loss in previous 3 mo			
> 3 kg	11.9	10.9	.009
1-3 kg	30.8	18.0	
No change	50.4	66.2	
Don't know	6.9	4.9	

that in practice there is a large degree of self-selection with regard to enrollment in the PACAM. Specifically, persons reporting enrollment in the PACAM were more likely to be from the lowest-income group, to be less educated, and to be more compromised in their preprogram health and nutritional status.

Integrating the PACAM into the health system has ensured access to curative care while at the same time providing an opportunity for effective disease prevention. In addition, the cost of implementing such a program corresponds to the incremental cost associated with the distribution of fortified foods and the associated staff time. Since the major setup costs of the national primary health infrastructure are already covered, the additional incremental costs are only a fraction of the total costs. Indeed, the annual cost of the nutritional supplement (US$51 million) represents only 2.5% of Chile's total annual health care budget of US$2 billion. Chile's approach to nutrition and health care has been criticized as being too expensive for most developing countries, yet the existing infrastructure has the advantage of providing the opportunity to implement additional programs while amortizing the cost of setting up the infrastructure.

The program has a demonstrated capacity to undertake some degree of self-monitoring. For example, it tracks process indicators by checking the amount of food distributed, the acceptability of the product, and the coverage of the program within the catchment area of each health center. The reported coverage of around 50% corresponds well with the data presented in this paper. This figure may seem low, but it is not unreasonable, given the fact that not all older people may need the program on the basis of their socioeconomic status. Indeed, a clear difference in coverage according to socioeconomic status was demonstrated in the sample, with 80% of those living in poor *comunas* but only 44% of those living in rich *comunas* being enrolled in the program. A limitation of the telephone interview data presented in this paper is the potential for introducing bias because of the nature of the sample, since having a telephone may be associated with other characteristics in which study participants and nonparticipants differ.

Special efforts are made through social support networks to identify the indigent, who may not be reached by the health care system. The program also has the ability to act upon new information as it arises. This is clearly demonstrated by the evaluation of the nutritional content of the fortified foods presented in this paper, which resulted in corrective actions being immediately put in place by program implementers.

Unfortunately, because the program was initiated without undertaking a needs assessment or baseline survey, the opportunity to evaluate its impact in a controlled manner was lost. In fact, the current paper demonstrates that the participants in the program are different from those potential beneficiaries who opted not to enroll in the program. Moreover, participants whose level of compliance with the program is higher are likely to be different from those who are less compliant. The evaluation efforts undertaken so far have addressed efficacy rather than effectiveness, and although this may be appropriate to optimize the technical aspects of the foods provided, it does not replace the need to assess program effectiveness.

The coverage of the program as presently implemented is dependent on the effort made at each health center to reach potential beneficiaries. This effort is highly variable, with some teams quite active in outreach activities while others respond mainly to spontaneous demand from the community. This may have been a reasonable approach during the initial stages of the program, but in order to increase its effectiveness, concerted efforts should now be undertaken to increase coverage of the program to all persons who may need it. In fact, program effectiveness is entirely dependent upon coverage and compliance, once efficacy has been accounted for.

Finally, as with all nutrition supplementation programs, the potential for adverse effects related to increased energy intake should be considered. The nutritional supplement was carefully designed after assessing the nutritional status and dietary intake of the potential beneficiaries. Most older people in Chile have a normal or even elevated body mass index [17], while on the other hand, dietary surveys suggest insufficient intake of key micronutrients [18]. The emphasis was therefore placed on micronutrient rather than macronutrient supplementation, and the supplement provides a micronutrient-enriched food with a modest amount of energy. This may be appropriate for most recipients, but for some, if the extra energy supplied is not offset by increased physical activity, excess weight gain may result, with the concomitant risks of obesity and metabolic consequences such as diabetes. This has not been fully explored to date, but in our assessments beneficiaries and program implementers suggested the need to integrate physical activity and exercise interventions within the PACAM to enhance the positive effects on health and quality of life of older people.

Acknowledgments

This research was supported by the Wellcome Trust (Health Consequences of Population Change Project Grant Number 069496). We gratefully acknowledge Dr. Hector Cori for facilitating the vitamin analysis conducted by Roche Analytical Laboratories.

References

1. United Nations. World Population Prospects, the 2000 revision, Volume 1: Comprehensive Tables. New York: United Nations, 2001.
2. Interamerican Development Bank. Social protection for the poor—a special report. Washington: IDB, 1999.
3. Lee JS, Frongillo EA Jr. Factors associated with food insecurity among U.S. elderly persons: importance of functional impairments. J Gerontol B Psychol Sci Soc Sci 2001;56:S94–9.
4. Lee JS, Frongillo EA Jr. Nutritional and health consequences are associated with food insecurity among U.S. elderly persons. J Nutr 2001;131:1503–9.
5. Kohrs MB, Czajka-Narins DM, Nordstrom JW. Factors affecting nutritional status of the elderly. In: Munro H, Danford DE, eds. Nutrition, aging and the elderly. New York: Plenum, 1989:305–33.
6. de Groot CPGM, van den Broek T, van Staveren W. Energy intake and micronutrient intake in elderly Europeans: seeking the minimum requirement in the SENECA study. Age Ageing 1999;28:469–74.
7. King JE, Mazariegos M, Valdez C, Castañeda C, Solomons NW. Nutritional status indicators and their interactions in rural Guatemalan elderly: a study in San Pedro Ayampuc. Am J Clin Nutr 1997;66:795–802.
8. WHO/TUFTS. Keep fit for life: Meeting the nutritional needs of older persons. Geneva: World Health Organization, 2002.
9. Castillo C, Uauy R, Atalah E, eds. Guías de Alimentación para el adulto mayor; bases para la acción. Santiago, Chile: Diario la nación, 1999.
10. Programa de Salud del Adulto Mayor (PSAM). Santiago, Chile: Ministerio de Salud, 2000.
11. Manual del programa de alimentación complementaria del adulto mayor (PACAM), 2nd ed. Santiago, Chile: Ministerio de Salud, 2001.
12. Bunout D, Barrera G, de la Maza P, Avendaño M, Gattas V, Petermann M, Hirsch S. The impact of nutritional supplementation and resistance training on the health functioning of free-living Chilean elders: results of 18 months of follow-up. J Nutr 2001;131:2441S–6S.
13. Atalah E, Benavides X, Cárdenas R, Barahona S, Espinoza M. Aceptabilidad y consumo de un suplemento alimentario en el adulto mayor. Rev Chil Nutr 2001;28:438–45.
14. Riumalló J, Pizarro T, Rodriguez L, Benavides X. Programas de suplementación alimentaria y de fortificación de alimentos con micronutrientes en Chile. Cuad Med Soc 2004;43:53–60.
15. Peláez M, Palloni A, Albala C, Alfonso JC, Ham-Chande R, Hennis A, Lebrao ML, Leon-Diaz E, Pantelides A, Pratts O. SABE—Survey on Health, Wellbeing and Aging in Latin America and the Caribbean, 2000. Washington, D.C.: Pan American Health Organization/World Health Organisation, 2004.
16. CASEN survey report 2000. Santiago, Chile: Ministerio de Planificación, 2001.
17. Albala C, Vio F, Kain J, Uauy R. Nutrition transition in Chile: determinants and consequences. Public Health Nutr 2002;5:123–8.
18. Atalah E, Benavides X, Avilia L, Barahona S, Cardnas R. Caracteristicas alimentarias de adultos mayores de comunas pobres de la Región Metropolitana. Rev Med Chile 1998;128:489–46.

Nutrition knowledge and practices, and consumption of vitamin A–rich plants by rural Nepali participants and nonparticipants in a kitchen-garden program

Katharine M. Jones, Sheila E. Specio, Parvati Shrestha, Kenneth H. Brown, and Lindsay H. Allen

Abstract

Food-based nutrition interventions, including kitchen gardens and nutrition education, offer a potentially sustainable approach to reducing multiple nutritional deficiencies, but they have been poorly evaluated in developing countries. In a poor region of the terai *(the flat, subtropical agricultural region that borders on India) in rural Nepal, we developed and evaluated the impact of a nutrition program added to the Market Access for Rural Development (MARD) Project. The primary objective of the MARD Project was to augment household income by increasing the production of high-economic-value crops. The objective of the nutrition program was to increase vitamin A and iron intakes by promoting kitchen gardens (training, technical assistance, and seed distribution) and nutrition education. One-third of the kitchen-garden program participants also attended nutrition education or agricultural training sessions that were part of the MARD Project. The program was evaluated after 36 months by a cross-sectional nutrition survey in 430 MARD households with kitchen gardens and 389 non-MARD control households. The lack of knowledge about nutrition, including the causes, prevention, and treatment of night-blindness and anemia, was remarkable. However, compared with control households, the kitchen-gardens group had significantly more nutrition knowledge (38% vs. 13% knew one of the causes of night-blindness, and 17% vs. 3% knew one of the causes of anemia), were more likely to feed special complementary foods to infants and to preserve food, and consumed more of 16 types of home-produced micronutrient-rich vegetables and fruits. Although the cross-sectional nature of the study limits our ability to attribute these differences to the program, we observed a striking lack of nutrition knowledge in these communities, and a clear opportunity to increase the intake of vitamin A through home production of vitamin A–rich plants.*

Key words: Agricultural development, complementary feeding, fruits and vegetables, iron, kitchen gardens, Nepal, nutrition education, vitamin A

Introduction

Micronutrient deficiencies continue to impose a substantial health, economic, and social burden worldwide. Because of lack of resources, religious observances, limited education, and resulting poor nutritional practices [1], many nonindustrialized countries, such as Nepal, struggle to maintain adequate nutritional status for the entire population. The consequences of poor nutritional status can include pregnancy complications; reduced work capacity due to anemia; compromised growth, development, cognitive function, behavior, and immunity; and increased risk of morbidity and mortality, especially in children and pregnant women [2, 3].

Supplementation with micronutrients is one strategy for improving nutritional status. This approach is limited by a strong dependency on international funding [4], an inability to reach all high-risk populations [5], unreliable and inconsistent delivery systems [6], dependence on individual compliance, and a tendency to target only subgroups of a population, often women and children under five years of age. Additionally, in the case of vitamin A deficiency, research suggests that high-dose supplementation alone is not sufficient to

Katharine M. Jones, Sheila E. Specio, Parvati Shrestha, Kenneth H. Brown, and Lindsay H. Allen are from the Program in International Nutrition, Department of Nutrition, University of California, Davis, California, USA. Lindsay Allen is now with the USDA-Western Human Nutrition Research Center, University of California, Davis. Parvati Shrestha was the Nutrition Specialist in the Market Access for Rural Development (MARD) Project.

Please address queries to the corresponding author: Lindsay H. Allen, Department of Nutrition, University of California, One Shields Avenue, Davis, CA 95616; e-mail: lhallen@ucdavis.edu.

The Market Access for Rural Development (MARD) Project was administered by Chemonics and supported by HMG-USAID Contract No. 367-0167.

Mention of the name of firms and commercial products does not imply endorsement by the United Nations University.

eliminate deficiency and should be accompanied by nutrition and health intervention programs [7–9].

An alternative or complementary approach to supplementation is to increase consumption of micronutrient-rich foods by establishing household kitchen gardens [10]. A kitchen-garden approach enables long-term sustainability through the harvesting and replanting of seeds and thereby supports household independence. Kitchen gardens can lead to overall improvement in diet with an increased intake of several nutrients. In rural Puerto Rico, for example, the presence of a kitchen garden was found to be a strong predictor of child nutritional status [11].

Several studies have evaluated the impact of the kitchen-garden approach on vitamin A status. The diversity [12] rather than the size [12, 13] of the kitchen garden positively affects vitamin A status. Households in Nepal that had fewer carotenoid-rich vegetables in the kitchen garden between October and March were more likely to have a child with xerophthalmia [13]. Consumption of dark-green leafy vegetables was correlated with a lower incidence of corneal disease in Indonesia [14] and with higher serum retinol concentrations in India [15]. In the Philippines, the value of the kitchen-garden approach was strongly supported by a vitamin A–rich crop yield from kitchen gardens, with average vitamin A production reaching over 130% of the recommended dietary intake per capita per harvest during peak season, and 84% during the lean months [16].

Despite these positive findings, some studies show that the kitchen-garden approach may not be a completely effective tool for decreasing vitamin A deficiency. In Indonesia, the association between serum retinol concentration and vitamin A intake from vegetables and fruits was much weaker than expected, possibly because of the low bioavailability of provitamin A [17–19]. In contrast, a recent study using spinach and sweet potatoes that were puréed to maximize provitamin absorption did find that plant sources improved liver retinol stores [20].

The success of kitchen gardens for improving nutritional status may be dependent on supporting interventions. For example, education to change knowledge, attitudes, and household dietary practices may also be required to effect positive changes in consumption and nutritional status. In Indonesia, social marketing played a critical role in increasing the consumption of vitamin A from plant and animal sources [21]. In some populations, social customs, such as the low status of dark-green leafy vegetables as food in Nepal [13], may interfere with implementation. Lack of knowledge of the causes and consequences of nutritional deficiencies should be expected to influence food choices, even in resource-poor populations.

Agricultural development activities can provide an opportunity to promote and support improved home production of nutrient-rich plants. The Market Access for Rural Development (MARD) Project, funded by the United States Agency for International Development (USAID), began in rural Nepal in 1997. The primary objective of the MARD Project was to augment household income by increasing production of high-economic-value crops, especially potatoes, tomatoes, onions, and cauliflower. Because these crops are low in micronutrients and because the expected increased income would not necessarily result in an increase in the purchase or consumption of nutritious foods [22], a secondary objective of the MARD Project was to increase the nutritional status of women and children under the age of five years through kitchen-garden and nutrition education and training. The University of California, Davis, particularly the Program in International Nutrition, was responsible for the nutrition component of the MARD Project. The present paper describes the kitchen-garden and nutrition education activities and the results of a cross-sectional survey designed to compare household nutrition knowledge and behavior, and the consumption of micronutrient-rich crops produced in the kitchen gardens, in participant and nonparticipant households.

Methods

Location and population

The MARD Project operated in six districts of the Lumbini-Gandaki Zones of the *terai* (the flat, subtropical agricultural region that borders on India) of southwestern Nepal. Nepal's districts are subdivided into Village Development Committees (VDCs), which contain between 9 and 14 wards, each with two or more villages. MARD Project activities were implemented in a subset of the VDC wards within four contiguous VDCs of each district (**fig. 1**) and planned to influence crop production in about 37,000 households. The majority of the population in the *terai* relies on farming as their principal occupation. Low economic status, illiteracy, poor hygiene and sanitation practices, nutritional stunting, and endemic micronutrient deficiencies are common within this region.

MARD Project

The primary focus of the MARD Project was to increase the production and sales of high-value crops by providing technical support to local farmers. The secondary focus was to improve the nutritional status of the target population by implementing a nutrition program. The MARD Project team was composed of a team leader, four specialists (in marketing, horticulture, nutrition, and data analysis), administrative support staff, and field staff (**fig. 2**). Field staff, who were

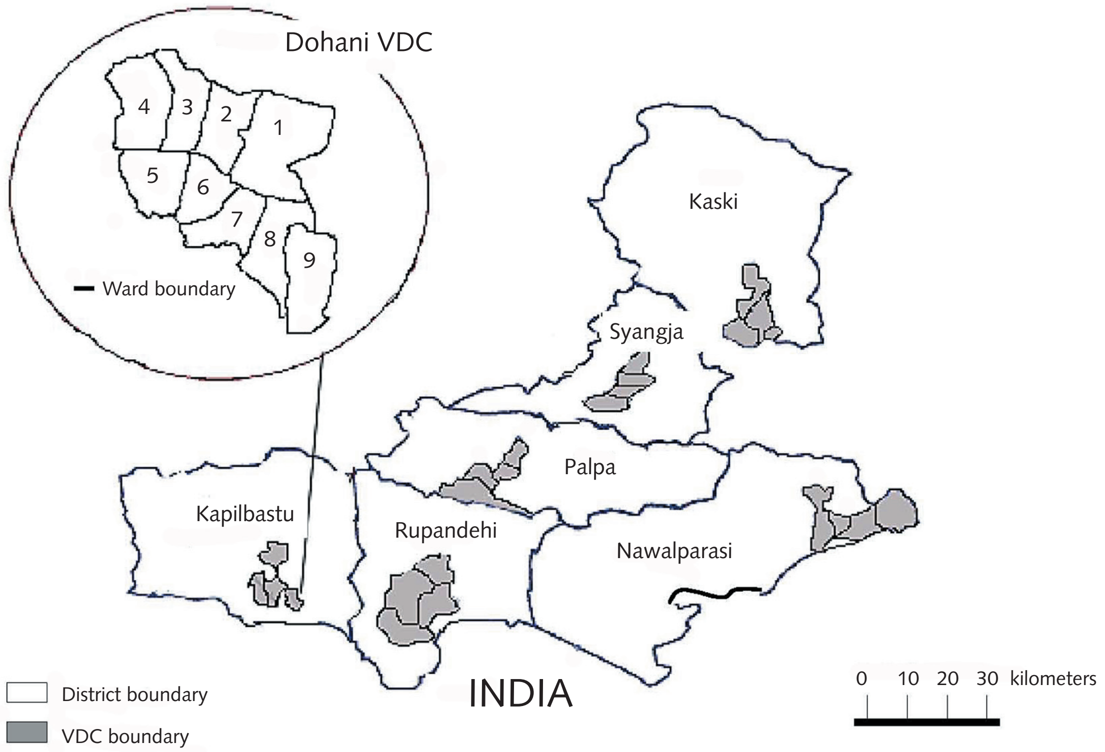

FIG. 1. Map of the Lumbini-Gandaki Zone, Nepal, where the MARD Project was responsible for implemented activities. Dohani Village Development Committee (VDC) in Kapilbastu District is highlighted to illustrate the division of VDCs into wards. Shaded areas are MARD VDCs

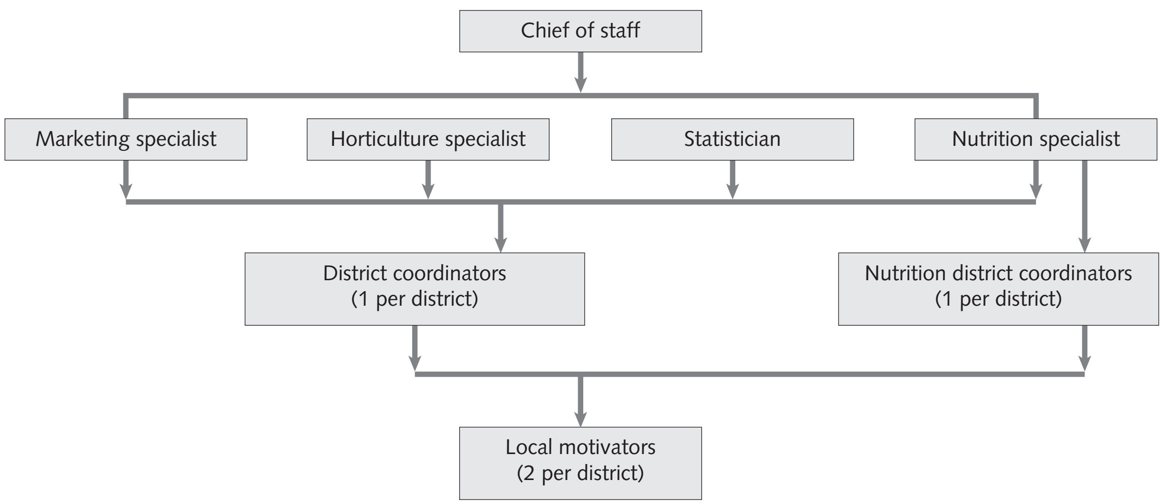

FIG. 2. Organization of the MARD Project

directly responsible for implementing MARD Project activities at the VDC and ward levels, included MARD District Coordinators (DCs, one per district), Nutrition District Coordinators (NDCs, one per district), and Local Motivators (two per district).

The Nutrition Specialist was in charge of designing interventions that would help achieve the secondary objective of the MARD Project. The DCs worked with all four MARD Project specialists, including the Nutrition Specialist, to implement MARD Project activities at the district and VDC levels, while the NDCs worked exclusively on nutrition activities. The Local Motivators were required to work with both the DCs and the NDCs within their assigned districts. The Horticultural Specialist was integral to the development of the kitchen-garden program.

Nutrition education

Development of the nutrition component of the MARD Project began with the investigation of nutrition-related beliefs and practices in rural Nepal. Eleven focus groups, composed of women with at least one child under the age of five years, were conducted. Based on the results, it was determined that nutrition knowledge, attitudes, and practices, especially those most relevant to pregnancy, lactation, and complementary feeding, were extremely poor and needed the most improvement [23]. The focus groups aided in the development and implementation of a culturally appropriate nutrition education training program.

As part of the general nutrition education and kitchen-garden strategy, Nutrition Demonstration Households (NDHs) were identified and established within each VDC (four per district). Field staff worked with the NDHs to develop a model kitchen garden and support the adoption of beneficial nutrition practices promoted by the MARD Project, such as consumption of micronutrient-rich foods within the household. The household was designed to serve as an example to the surrounding community of the benefits to be gained by maintaining a kitchen garden and adopting healthy nutrition practices. MARD Project high-economic value crop demonstration sites were located in close proximity to the NDH to maximize technology diffusion. The NDCs and Local Motivators visited the NDHs at least once a week to monitor practices, distribute seeds, and provide instruction. During the last year of MARD Project nutrition education implementation, additional NDHs were established.

Educational materials were developed in the form of fact sheets for farmers, and training sessions were conducted in all six MARD Project districts. Each of the fact sheets contained production tips and nutrition facts relevant to a specific crop. Nutrition facts often included a list of the nutrients in the crop, the role of these nutrients in the body, and cooking tips. The fact sheets were distributed to literate farmers, who were encouraged to share the information with other community members. The Nutrition Specialist and the NDCs facilitated education on five topics: nutrition education training, causes of vitamin A and iron deficiency and local food sources of these nutrients, kitchen-garden training, recipe demonstration and improved hygiene and sanitation practices, and modern food-preservation techniques.

Nutrition education training sessions covered nutrition during pregnancy (adverse effects of undernutrition, adequate weight gain, need for iron and other supplements, and advice to eat more of specific foods); breastfeeding (importance, and additional maternal food and fluid requirements); complementary feeding practices (appropriate age for complementary feeding, recipes based on local foods); vitamin A (night blindness recognition, cause and treatment, specific excellent and good plant sources and how each can be grown, animal-source foods and methods of poultry production, best food preparation methods, recipes, importance of avoiding high dose supplements until lactation); and iron (causes and recognition of anemia, food sources, enhancers and inhibitors of absorption, cooking in iron pots, iron supplements). The second training focused specifically on vitamin A, with the importance of vitamin A and vitamin A–rich foods emphasized in training sessions 3, 4, and 5.

Training sessions were held in the NDH with 30 to 40 men and women attending, usually a village women's group or farmer's group, with each person representing a different household. Each of the five training sessions started with a brief lecture followed by hands-on activities. For example, the kitchen-garden training included a viewing of the NDH garden and identification of crops, while the recipe demonstration/improved hygiene and sanitation practices training included actual cooking and eating of foods using vitamin A–rich recipes. Each of the five sessions lasted approximately two hours and was held one day per week in each VDC. Toward the end of the project, recipe demonstration/improved hygiene and sanitation training sessions were held most often, while the nutrition education training took place approximately once a month.

In addition to these nutrition education activities held in the NDH, the nutrition educators also provided additional training sessions to groups of 10 to 20 individuals as part of the ongoing meetings of women's groups and farmers' groups (total 161 individuals). During a session of approximately 1 to 2 hours, the same information as that in the NDH sessions was provided, but with more emphasis on specific issues of interest to each group, e.g., on vitamin A during pregnancy and lactation for the women's groups, and how to grow food sources of vitamin A for the farmers' groups. Thus these additional sessions were intended to reinforce the information given in the NDH sessions.

Kitchen gardens

Project activity aimed at increasing the production and consumption of vitamin A–rich crops was initiated 36 months prior to evaluation in the Lumbini-Gandaki Zones; however, the kitchen-garden component was added six months later. During this time, the NDHs were chosen and the Nutrition and Horticultural Specialists identified high-economic-value vitamin A plants that were growing within the region and could together provide continued production year-round. Broad leaf, mustard leaf, spinach, cress, Swiss chard, fenugreek, amaranth, carrot, broccoli, Helen Keller sweet potatoes (a variety high in carotenoids), colocasia, kangkung (water spinach, *Ipomoea aquatica*), climbing spinach, pumpkin, and papaya were identified, and seeds were distributed by the NDCs and Local Motivators during the appropriate seasons. Mango plants were provided. Importantly, a workshop revealed that the baseline knowledge of many Agricultural Specialists concerning good sources of specific nutrients, such as vitamin A, was often lacking or incorrect.

Model kitchen gardens were first established at the NDHs with eventual diffusion to the neighboring households. MARD Project field staff visited household kitchen gardens, providing horticultural instruction and seeds and offering nutrition education to the communities. Local business was supported and the intervention was made sustainable by training and mobilizing local "agrovet" businesses to make vitamin A–rich seeds and other supplies available. The Helen Keller sweet potatoes were imported from Bangladesh; the local varieties in Nepal had red skin with white flesh and were traditionally consumed only on special days.

Evaluation

A cross-sectional survey was designed to gather data on general household characteristics and socioeconomic status, crop and livestock production, maternal care and practices during pregnancy, food preservation and storage practices, hygiene and sanitation, and general nutrition knowledge. Ten interviewers, who were familiar with the area and the local languages, were hired to conduct the survey. The nutrition team trained interviewers for 3.5 days before they began data collection.

The project was approved by the Office of Human Research Protection at the University of California, Davis. Additionally, consent to conduct the survey was obtained from the VDC chairmen prior to initiation, and oral consent was obtained from each household immediately prior to the household interview.

The survey was implemented in Rupandehi and Kapilbastu, the two districts considered most at risk for malnutrition because of their high prevalence of vitamin A deficiency [24]. All households participating in the kitchen-garden program in these districts were selected for interview (n = 430). Because of political instability in the surrounding region, control households (n = 389) were located within MARD Project VDCs in wards that received no direct assistance from the project (i.e., no kitchen-garden support, nutrition education, or agricultural support) (**fig. 3**). Interviewers visited every 3rd to 10th household within the control wards based on a number (between 3 and 10) that was randomly preselected and changed daily.

Self-identified primary caregivers responded to questions, but additional members of the household were often present to assist in answering questions related to food production. After the interview, each household was compensated with two bars of soap. For quality control, surveys were reviewed for consistency by the coordinator.

Statistical analysis

The hypothesis tested was that participants in the kitchen-garden program would have better nutrition knowledge and practices and consume more home-produced micronutrient-rich foods than those in the nonparticipant control group. The EpiInfo statistical program was used to compare continuous

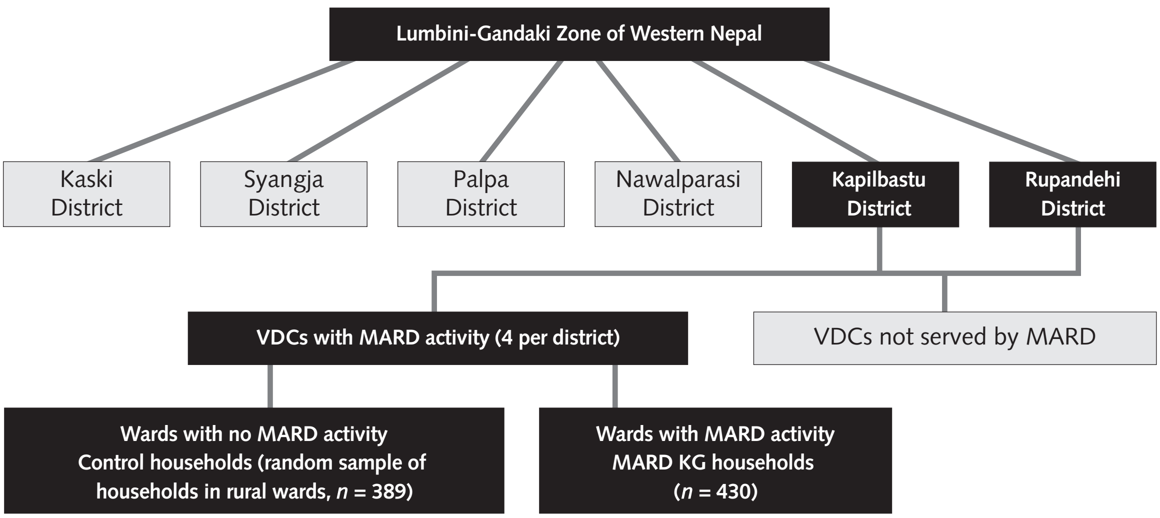

FIG. 3. Organization of household selection for survey. KG, kitchen garden; VDCs, Village Development Committees

variables between groups by *t*-tests and analysis of covariance and categorical variables by Pearson's χ^2 test. Regression analysis was used to control for potentially confounding socioeconomic variables that differed between groups.

Results

Household composition, caregiver characteristics, and socioeconomic status were similar in the kitchen-garden and control groups (**table 1**). As expected in this rural community, farming was the primary occupation. In both groups, the caregivers had an average of one child less than five years old. Less than 10% of the caregivers in both groups were currently pregnant, and just over half were lactating. Approximately two-thirds of the caregivers in both groups were illiterate.

TABLE 1. Characteristics of kitchen-garden and control households

Characteristic	Kitchen-garden ($n = 430$)	Control ($n = 389$)
Mean size of household	8.9	8.3
Mean age of caregiver (yr)	33.1 ± 8.9	32.6 ± 9.5
Caregivers pregnant (%)	8.1	4.9
Caregivers lactating (%)	50.7	54.9
Caregivers illiterate (%)	65.6	72.5
Electricity (%)	26.7*	35.8
Telephone (%)	1.4	2.1
Radio (%)	48.1	41.8
Television (%)	20.0	24.0
Bicycle (%)	90.2**	81.4
No. of cows or buffaloes/household	1.8 ± 2.2*	1.1 ± 1.6
No. of goats/household	1.3 ± 2.0*	1.1 ± 1.5
No. of oxen/household	1.7 ± 1.3*	1.3 ± 1.3
No. of poultry or pigeons/household	2.6 ± 6.3	2.3 ± 5.2

*$p < .05$; **$p < .005$, significantly different from control group.

Selected possessions, (bicycle, telephone, radio, and television), indicators of housing quality (e.g., type of roof, presence of electricity), and the average number of livestock per household were used to assess socioeconomic status. Slightly more control households had electricity, whereas more households with kitchen gardens owned a bicycle. Households with kitchen gardens also owned more livestock (cows or buffaloes, oxen, and goats), but not more poultry. Many households did not own any livestock or poultry, and less than 5% of all households were involved in pig production or aquaculture. The variables that showed statistically significant differences between groups were used as covariates when the control and participant households were compared in subsequent analyses. Unless otherwise stated, there were no effects of covariates on outcome variables.

Nutrition knowledge of caregivers in households with kitchen gardens and caregivers in control households

MARD Project households with kitchen gardens scored an average of 2.3 ± 1.9 out of 6 possible points on the nutrition knowledge test versus 1.1 ± 1.5 points for the control households ($p < .0001$) (**table 2**). Surprisingly and unacceptably, only 38% of households with kitchen gardens and 13% of controls were able to identify a cause of night-blindness, even though the condition is widely recognized in this region of Nepal and there are national programs for its prevention. Correct responses, given in descending order of frequency, were "lack of dark-green leafy vegetables," "lack of vitamin A," "lack of yellow vegetables and fruit," and "lack of eggs, milk,

TABLE 2. Percentage of kitchen-garden, control, and MARD vitamin A awareness trainees who responded correctly to nutrition knowledge survey questions

Question	Kitchen-garden ($n = 418$)	Control ($n = 385$)	MARD vitamin A awareness trainees ($n = 161$)[a]
What causes night-blindness?	38.1	13.3	51.9
Name foods rich in vitamin A	52.0	22.6	67.7
What causes anemia?	17.1	3.4	—
Name foods rich in iron	25.6	9.8	—
At what age should children be fed foods other than breastmilk?	17.0	10.1	—
Name the ingredients of a nutritious complementary food	61.8	50.5	—
Average number of correct responses (0-6)	2.3 ± 1.9*	1.1 ± 1.5	—

a. The subgroup of the KG program recipients who received additional education on vitamin A in women's groups and farmer's groups.

*$p < .0001$, significantly different from control group.

small fish, and/or liver." In total, 52% of households with kitchen gardens and 23% of control households could name at least one food rich in vitamin A. In both groups, the most common response was "dark-green leafy vegetables," followed by "yellow fruits," "yellow vegetables," "milk," "eggs," "small fish," and "liver."

Caregivers in both groups had great difficulty answering questions about iron and anemia, but the kitchen-garden group performed better. Only 17% of caregivers from households with kitchen gardens and 3% of those from control households were able to identify a cause of anemia, and when asked to name foods rich in iron, 26% of caregivers from households with kitchen gardens and 10% of those from control households could name at least one good source.

Exclusive breastfeeding of children until the age of five to six months was promoted in nutrition education training sessions. When asked at what age food other than breastmilk should be given to children, 17% of caregivers from households with kitchen gardens and 10% of those from control households answered five to six months. About three-quarters of the respondents in both groups believed that food should be given after six months of age, whereas the remainder believed it should be provided before the age of five months. The correct response was intended to be "five to six months." However, because of the somewhat ambiguous nature of the question, some caregivers who answered "after six months" may also have been correct. Finally, 62% of caregivers from households with kitchen gardens and 50% of those from control households could name the ingredients of a nutritious complementary food, the composition of which had been discussed in MARD Project nutrition education training.

The MARD Project provided vitamin A awareness training, outside of the nutrition education offered in kitchen-garden training, to 37.7% of households in the kitchen-garden group. A higher proportion (52%) of participants in this additional MARD Project vitamin A awareness training could identify a cause of night-blindness, compared with 28% of those in the kitchen-garden group who had not participated in the additional training, and 13.3% of those in the control group. Similarly, 68% of those who received additional training could name at least one source of vitamin A, versus 43% of those who were only educated about vitamin A in the kitchen-garden program and 23% of controls (**table 2**).

Production and consumption of micronutrient-rich vegetables

The households described production and consumption patterns of 16 micronutrient-rich vegetables promoted by the MARD Project. Self-reported data on the level of household production and consumption were recorded for eight dark-green leafy vegetables (broad leaf, mustard leaf, Swiss chard, fenugreek, amaranth leaf, spinach, kangkung, and climbing spinach), and eight other crops (broccoli, coriander, colocasia, Helen Keller sweet potato, carrot, ripe pumpkin, ripe papaya, and ripe mango).

Household production for consumption was higher in the kitchen-garden group for all vegetables (**fig. 4**). Conversely, more control households reported buying vegetables, except for Swiss chard, for home consumption. Seasonal consumption of all vegetables was also assessed on an eight-point scale. For 13 vegetables (all except colocasia and Helen Keller sweet potato) and for ripe mango, the reported frequency of consumption was significantly higher in the kitchen-garden group. In both groups, broad leaf, mustard leaf, spinach, coriander, carrot, ripe pumpkin, and ripe mango were consumed most often, followed by ripe papaya, Helen Keller sweet potato, colocasia, amaranth, and fenugreek. Two-thirds of all houses reported never eating climbing spinach, kangkung, broccoli, or Swiss chard.

Food preservation and storage

A variety of vegetables are preserved in rural Nepal. In this survey, cauliflower, cabbage, gourd, eggplant, tomato, radish, and sag were often cited as being preserved by respondents. Specialized foods such as *masoura* and *sinki* (dried grains and vegetables) were also commonly named. In this region, foods are preserved by solar drying and then stored in plastic or foil wrap or in a container such as an earthenware pot.

More households with kitchen gardens reported preserving foods in the previous year (86.9% vs. 60.1% of controls, $p < .005$) and preserving enough food to last through the season of scarcity (49.1% vs. 38.3%, $p < .05$). Although this variable was also correlated with the presence of electricity in the household, the difference between groups was still significant after controlling for electricity and all other baseline differences. Many caregivers from households with kitchen gardens (29%) reported attending a special MARD Project training session on food preservation, outside of the specific activities of the kitchen-garden program. This course covered methods of solar drying with locally built equipment, building homemade storage facilities for sweet potatoes, home dehydration, and minimizing damage and food wastage after harvest. Of the households with kitchen gardens that had participated in the training, 95.8%, versus 77.9% of those not participating in the training, reported preserving foods in the last year, compared with 60.1% of controls ($p < .005$).

Consumption of animal-source foods

Animal-source food intake did not differ between groups, in spite of nutrition education to promote

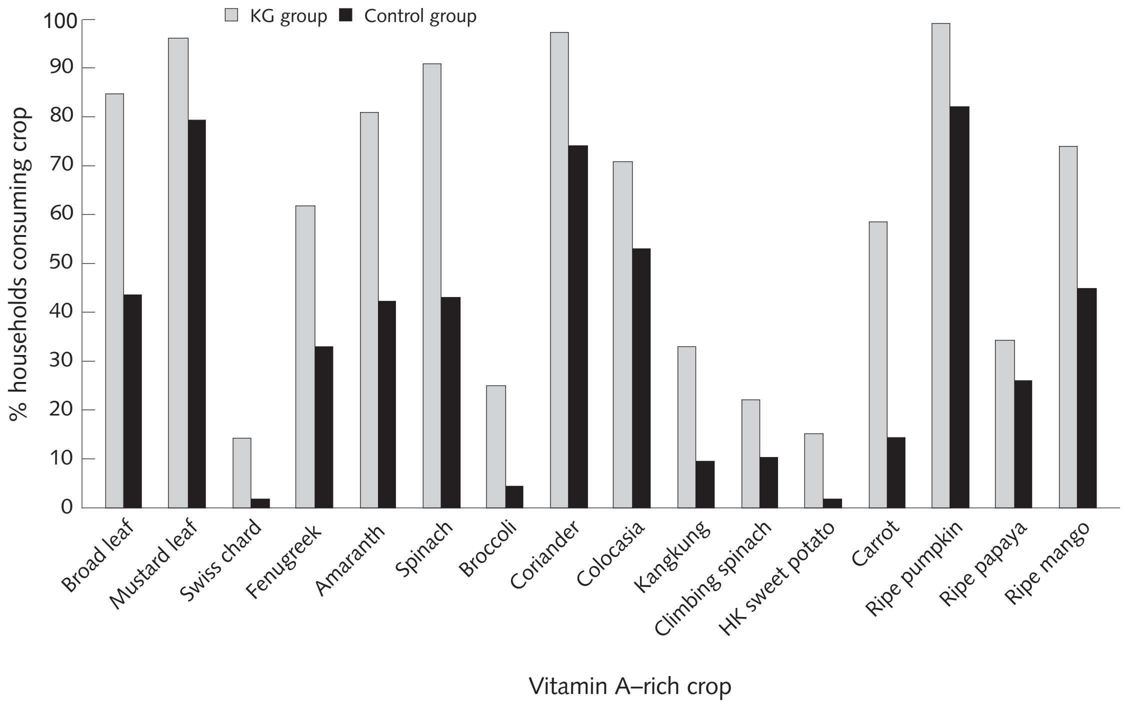

FIG. 4. Households with kitchen gardens (KG) reported consuming more household-produced micronutrient-rich fruits and vegetables promoted by the MARD Project than did control households ($p < .05$ for papaya; $p < .001$ for all other crops)

its consumption. The mean frequency of consumption of eggs, small fish, liver, and meat was less than once a week in both groups. Seventy-five percent of all households did not consume eggs on a weekly basis, whereas the mean frequency of consumption in households reporting production of eggs was 2.4 times per week. The frequency of milk consumption was greater than for the other four animal-source foods, with households with kitchen gardens consuming milk 4.3 times a week on average, and control households consuming milk 3.5 times per week. The group difference was not statistically significant after controlling for ownership of a cow or buffalo by the household. In milk-producing households of both groups, the mean frequency of milk consumption was 7.5 times per week, compared with 1.8 times per week for nonproducing households.

Maternal nutrition practices

The nutrition education message of the MARD Project included the need to consume more energy and higher-quality foods such as animal products during pregnancy. Exclusive breastfeeding until the age of five to six months was promoted, as was feeding of colostrum. More caregivers in control households reported adjusting their diet to consume "special foods" during pregnancy (91.9% vs. 82.8%, $p < .005$) (**table 3**). This variable was also correlated with the presence of electricity in the household, but the intergroup difference was still significant after this variable and all other baseline differences had been controlled for. Animal-source foods such as fish, meat, eggs, milk, and ghee were commonly identified, as were a variety of nuts and dried fruits, such as *chhorha* (dates), coconut, and raisins. Frequently mentioned were foods associated specifically with pregnancy, such as *jwano* soup (soup from omum seeds), *bheli* (sugar soup), and *sot* (herbs mixed with flour and sugar). Many women also stated that consumption of staple foods such as rice, *dal*, and *roti* was increased in pregnancy.

There were no differences between households with kitchen gardens and control households in the percentage of caregivers who reported feeding colostrum to newborns, or in the reported length of exclusive breastfeeding. In all, 78.2% and 62.5% of households

TABLE 3. Percentage of kitchen-garden and control caregivers reporting nutrition practices

Practice	Kitchen-garden ($n = 413$)	Control ($n = 382$)
Adjust diet in pregnancy	91.9**	82.8
Feed colostrum	72.9	66.5
Feed milk to children under 5 yr of age	74.8**	64.7
Feed lito to children	25.4*	17.5
Feed jaulo to children	46.5**	24.7

* $p < .05$; ** $p < .005$, significantly different from control group.

with kitchen gardens and control households, respectively, reported that animal milk (buffalo, cow, or goat) was the first drink other than breastmilk given to their children (a nonsignificant difference), with buffalo milk specified most often. The remaining caregivers gave water, fruit juice, or some other liquid, such as *bheli* (a sugar soup), to their children as a first food. The first foods most commonly mentioned were staples such as rice, *roti*, and *dal* and the complete meal of "*dal bhat tarkari*." Some caregivers named traditional high-quality complementary foods such as *lito*, *jaulo*, *kichari* (cereal and legume gruels), or commercially available infant cereals, but this was less common.

There was no difference between households with kitchen gardens and control households in the percentage of caregivers who reported feeding milk (other than breastmilk) to children less than five years of age (74.8% of households with kitchen gardens and 64.7% of control households). However, there was a strong correlation between this behavior and household ownership of a cow or buffalo (data not shown). In both groups, most women (two-thirds) reported feeding buffalo milk, followed by cow milk (29.6%), goat milk (5.2%), and powdered milk (3.6%). Consumption of *lito* and *jaulo* (higher-quality traditional complementary foods) was higher in the kitchen-garden group (**table 3**). This variable was also correlated with the presence of electricity and a work animal in the household, but the difference was still significant after these associations and all baseline differences had been controlled for.

Hygiene and sanitation

The number of households with access to a latrine (15.2% of those with kitchen gardens and 23.4% of controls) was not significantly different between groups. For the kitchen-garden and control groups combined, about three-quarters of households reported that the latrine was not more than 50 feet away from the house. Soap and water was the most popular method of cleansing the hands after using the latrine. Mud, ash, and plain water were also used.

Caregivers self-reported hygienic practices, specifically how often they washed their hands before preparing food and before feeding children, and how often children were made to wash their hands after using the latrine and before eating (**table 4**). A scale from 1 (every time) to 4 (never) was used. In all situations, the kitchen-garden group scored significantly higher than the control group ($p < .05$). Caregivers were asked what care they took to keep flies away from food when cooking and away from their children's food and face. According to the same scaling system, households with kitchen gardens scored higher ($p < .005$). Households that had also participated in MARD Project training sessions on sanitation and hygiene (49% of those with kitchen gardens) scored higher than untrained respondents (kitchen-garden households and controls combined) on every behavior ($p < .005$).

Discussion

The cross-sectional design of this study means that it is not possible to prove causality between participation in the nutrition and kitchen-garden program and the better nutrition knowledge and practices of the participants. The overall very poor performance on the nutrition knowledge test, even in the MARD Project kitchen-garden group, highlights the need for more extensive community nutrition education. Knowledge of the causes of night-blindness, which may affect 16% to 25% of pregnant women in the *terai* [25, 26], and of the causes of anemia is shockingly poor. The better knowledge of vitamin A in households with kitchen

TABLE 4. Reported hygiene behaviors

Survey question	Kitchen-garden ($n = 422$)	Control ($n = 385$)	MARD hygiene and sanitation trainees ($n = 209$)
Caregivers wash hands			
Before preparing food	$1.16 \pm 0.45^{*}$	1.24 ± 0.52	$1.08 \pm 0.32^{***}$
Before feeding children	$1.43 \pm 0.75^{**}$	1.65 ± 0.82	$1.35 \pm 0.68^{***}$
Children made to wash hands			
After using the latrine	$1.52 \pm 0.82^{**}$	1.72 ± 0.85	$1.40 \pm 0.79^{***}$
Before eating	$1.57 \pm 0.86^{**}$	1.80 ± 0.84	$1.56 \pm 0.76^{***}$
Caregivers attempt to keep flies away			
From children's food	$1.74 \pm 0.90^{**}$	1.98 ± 0.85	$1.69 \pm 0.91^{***}$
While cooking	$1.41 \pm 0.68^{**}$	1.64 ± 0.72	$1.32 \pm 0.63^{***}$

Scale: 1 = always, 2 = most of the time, 3 = sometimes, 4 = never.
$^{*}p < .05$; $^{**}p < .005$, significantly different from control group; $^{***}p < .005$, significantly different from households with no MARD Project training.

gardens that participated in the additional MARD Project vitamin A awareness training, compared with households with kitchen gardens that did not participate, and the better performance of the latter compared with controls, suggest that intensive nutrition education training can improve nutrition knowledge in these communities.

Nutrition practices were better in the kitchen-garden group, but these practices were reported and not observed. Many of the caregivers in households with kitchen gardens had received MARD Project nutrition training as well as kitchen-garden training, and they may have adjusted their responses on the basis of messages received in these programs. For example, half of the kitchen-garden group had received training on hygiene and sanitation practices, and they may have reported more frequent application of hygienic practices, such as handwashing and clean food preparation, even if they had not actually adopted these practices. However, the increased reports of good practices in the kitchen-garden group reflect, at least, that information provided in training sessions was retained by the participants.

By providing quality seed and technical advice on the production of nontraditional vegetables, the MARD Project increased household access to micronutrient-rich plant-source foods. Increased production by MARD Project households with kitchen gardens also may have increased the availability of these foods to other members of the community, since many households reported selling extra kitchen-garden produce in the local market. Although some nontraditional vegetables (such as Swiss chard) were rejected by the community, many others (such as broccoli) were accepted and integrated into the diet. Increasing production of micronutrient-rich foods in the kitchen garden is an especially promising strategy for combating childhood malnutrition, because in general Nepali children are not fed special complementary foods but share the family's meal [23]. Caregivers also reported increased palatability of the diet and less time spent traveling to the market as benefits of a kitchen garden.

The diet in Rupendehi and Kapilbastu, and in the *terai* in general, rarely includes animal products, with the exception of milk. Fish, meat, and eggs were all reported to be consumed an average of less than once per week in both groups, and many caregivers reported eating these foods less than once every several months. In addition to the prohibitive cost of animal-source foods, many families in Nepal follow a pattern of food avoidance mandated by religion or caste. A total of 89 kitchen-garden households and 32 control households reported avoiding eggs, fish, and meat, and many other households avoided one of these foods. These constraints reduce the potential role of fish, meat, and eggs in the diet, and even in households that produce their own animal products, these are often prized commodities, consumed only for special events.

Milk, which is a well-accepted food, may play an important role in a diet otherwise devoid of animal products. Even in households that did not own a milk-producing animal, the average frequency of consumption of milk for the kitchen-garden and control groups combined was 1.8 times per week. Households that produced their own milk consumed milk an average of 7.5 times per week. Some households reported consuming milk up to 21 times per week, or 3 times per day. Milk is an important source of nutrients for children, with 75% of kitchen-garden households and 65% of control households feeding milk (not including breastmilk) to children under five years of age.

The kitchen-garden approach has the potential to further improve nutrition in the Lumbini-Gandaki Zone. It was obvious from observing activities and land use in the communities that provision of seeds and technical advice increased the production of nontraditional micronutrient-rich vegetables, and participants in the kitchen-garden program had better nutrition knowledge and behavior. The combination of agricultural training with nutrition education provides participants with knowledge of the importance of food and nutrition, as well as practical advice on how to grow and prepare nutritious foods. For example, the preparation and distribution of calendars that listed appropriate times of the year for planting and cultivating specific seeds assisted the household implementation of the kitchen gardens. The Agricultural Production Specialists also learned a great deal about the importance of nutrition and how agriculture can be used to improve nutritional status. Prior to the work of the nutrition team, the Horticultural Specialists lacked basic information about the importance of micronutrients in the diet and sources of nutrients. For example, we were informed that the local white sweet potatoes provided vitamin A because they had red skins. Some seeds (such as mustard seed) were perceived to be good sources of carotenoids and iron, even though they could be consumed only in very small quantities. Even though the kitchen-garden approach may be less cost-effective than supplementation for the short-term elimination of micronutrient deficiencies, it makes micronutrient-rich foods accessible to the entire household and can improve the quality of diet and life for a lifetime.

Acknowledgments

We thank our dedicated enumerators in the field: Devi Pokhrel, Bhagbati Gaire, Meena Gharti, Ranju Gupta, Babita Khati, Deva Kunwar, Gita Paudel, Gita Sharma, Sharmila Shrestha, and Devi Thapa. We wish to acknowledge Dr. B. B. Mathema and Dr. Larry Morgan as MARD Chiefs of Staff; Kumar Shrestha of the Nepali Technical Assistance Group for advice and assistance; Dr. Lisa Kitinoja of the University of California, Davis, for training in small-scale food preservation; Dr. John Woods of Chemonics for developing the communication strategy; and the entire project team for all their accomplishments.

References

1. Johns T, Booth SL, Kuhnlein HV. Factors influencing vitamin A intake and programmes to improve vitamin A status. Food Nutr Bull 1992;14:20–33.
2. Allen LH, Gillespie SR. What works? A review of the efficacy and effectiveness of nutrition interventions. ACC/SCN Nutrition Policy Paper No. 19. Geneva: United Nations Administrative Coordinating Committee/Subcommittee on Nutrition, in collaboration with Asian Development Bank, Manila, 2001.
3. Kapil U, Bhavna A. Adverse effects of poor micronutrient status during childhood and adolescence. Nutr Rev 2002;60:S84–90.
4. Fiedler J. The Nepal National Vitamin A Program: prototype to emulate or donor enclave? Health Policy Plan 2000;15:145–56.
5. Reifen R, Ghebremeskel K. Vitamin A during pregnancy. Nutr Health 2001;15:237–43.
6. Bloem MW, Hye A, Wijnroks M, Ralte A, West KP Jr, Sommer A. The role of universal distribution of vitamin A capsules in combating vitamin A deficiency in Bangladesh. Am J Epidemiol 1995;142:843–55.
7. West KP Jr, Katz J, Shrestha SR, LeClerq SC, Khatry SK, Pradhan EK, Adhikari R, Wu LS, Pokhrel RP, Sommer A. Mortality of infants < 6 mo of age supplemented with vitamin A: a randomized, double-masked trial in Nepal. Am J Clin Nutr 1995;62:143–8.
8. Cohen N, Rahman H, Mitra M, Sprague J, Islam S, Leemhuis de Regt E, Jalil MA. Impact of massive doses of vitamin A on nutritional blindness in Bangladesh. Am J Clin Nutr 1987;45:970–6.
9. Pereira SM, Behum A. Studies in the prevention of vitamin A deficiency. Am J Clin Nutr 1969;22:858–62.
10. Bittenbender HC. Home gardens in less developed countries. Horticult Sci 1985;20:645–9.
11. Immink MDC, Sanjur D, Colon M. Home gardens and the energy and nutrient intakes of women and preschoolers in rural Puerto Rico. Ecol Food Nutr 1991; 11:191–9.
12. Bloem MW, Huq N, Gorstein J, Burger S, Kahn T, Islam N, Baker S, Davidson F. Production of fruits and vegetables at the homestead is an important source of vitamin A among women in rural Bangladesh. Eur J Clin Nutr 1996;50(suppl 3):S62–7.
13. Shankar AV, Gittelsohn J, Pradhan EK, Dhungel C, West KP Jr. Home gardening and access to animals in households with xerophthalmic children in rural Nepal. Food Nutr Bull 1998;19:34–41.
14. Tarwotjo I, Sommer A, Soegiharto T, Susanto D, Muhilal. Dietary practices and xerophthalmia among Indonesian children. Am J Clin Nutr 1982;35:574–81.
15. Lala VR, Reddy V. Absorption of β-carotene from green leafy vegetables in undernourished children. Am J Clin Nutr 1970;23:110–3.
16. Bayani EM. Reducing micronutrient malnutrition: policies, programmes, issues, and prospects— dietary diversification through food production and nutrition education. Food Nutr Bull 2000;21:521–6.
17. de Pee S, Bloem MW, Gorstein J, Sari M, Satoto, Yip R, Shrimpton R, Muhilal. Reappraisal of the role of vegetables in the vitamin A status of mothers in Central Java, Indonesia. Am J Clin Nutr 1998;68:1068–74.
18. de Pee S, Bloem MW, Tjiong R, Martini E, Satoto, Gorstein J, Shrimpton R, Muhilal. Who has a high vitamin A intake from plant foods, but a low serum retinol concentration? Data from women in Indonesia. Eur J Clin Nutr 1999;53:288–97.
19. Schipani S, van der Haar F, Sinawat S, Maleevong K. Dietary intake and nutritional status of young children in families practicing mixed home gardening in northeast Thailand. Food Nutr Bull 2002;23:175–80.
20. Haskell MJ, Jamil KM, Hassan F, Peerson JM, Hossain MI, Fuchs GJ, Brown KH. Daily consumption of Indian spinach (Basella alba) or sweet potatoes has a positive impact on total-body vitamin A stores in Bangladeshi men. Am J Clin Nutr 2004;80:705–14.
21. de Pee S, Bloem MW, Satoto, Satoto, Yip R, Sukaton A, Tjiong R, Shrimpton R, Muhilal, Kodyat B. Impact of a social marketing campaign promoting dark-green leafy vegetables and eggs in Central Java, Indonesia. Int J Vitam Nutr Res 1998;68:389–98.
22. Marek T, Brun T, Reynaud J. Do home garden projects improve income and nutritional status? A case study in Senegal. Food Nutr Bull 1990;12:20–5.
23. Haskell M, Shrestha P, Manadhar D, Jones K. Food and nutrition-related beliefs and practices of women with young children in the Rapti zone of Nepal. Kathmandu, Nepal: MARD/Rapti Technical Report, 1998:12.
24. Shrestha P, Morgan L. The impact of improved nutrition knowledge and practices on night blindness in MARD project areas. Kathmandu, Nepal: MARD/Lumbini-Gandaki Technical Report, 1999:33.
25. Dahal B. Food consumption and nutrition baseline and impact assessment survey for Rapti and Bheri zones. Kathmandu, Nepal: Agricultural Projects Services Centre, 1996.
26. Katz J, West KP Jr, Khatry SK, Thapa MD, LeClerq SC, Pradhan EK, Pokhrel RM, Sommer A. Impact of vitamin A supplementation on prevalence and incidence of xerophthalmia in Nepal. Invest Ophthalmol Vis Sci 1995;36:2577–3.