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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.

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

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.

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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 assess-

ment 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

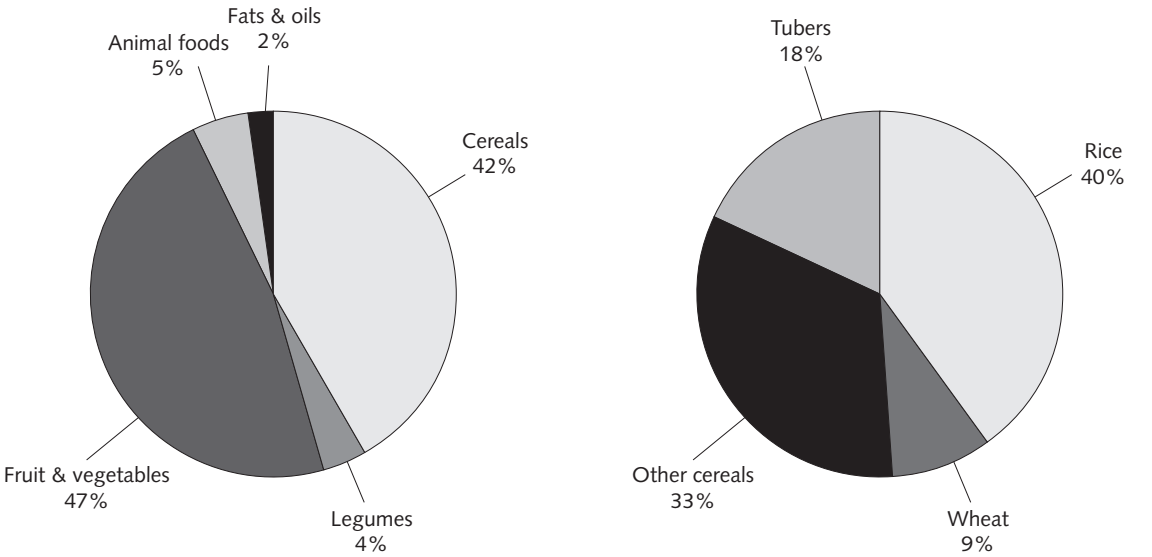

FIG. 1. Food-consumption pattern of 19- to 54-year-old men

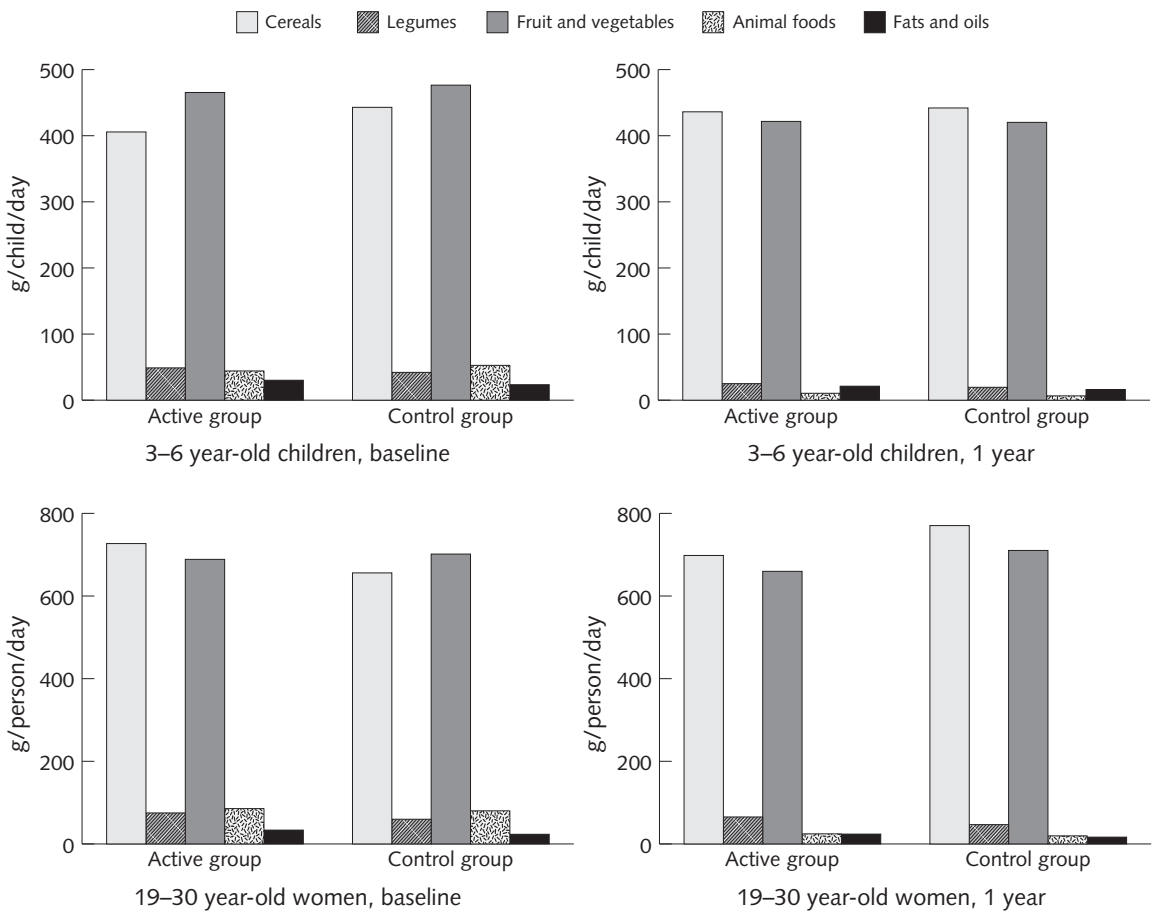

FIG. 2. Changes in food consumption (g/person/day) between baseline and one year for 3- to 6-year-old children and 19- to 30-year-old women

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

	Fortified group			Control group		
Sex and age	*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 to be of high quality. There were no complaints of adverse effects. The two sauces were reported to taste the same.

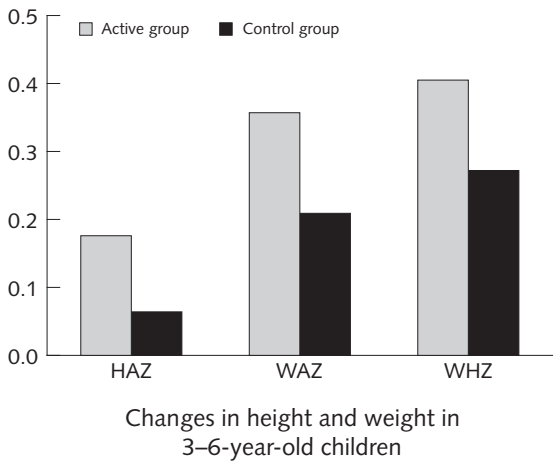

FIG. 3. Changes in height and weight of three- to six-year-old children between baseline and one year after intervention. HAZ, height-for-age Z score; WAZ, weight-for-age Z score; WHZ, weight-for-height Z score. *$p < .05$ compared with control group

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.

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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

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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.

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

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.

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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).

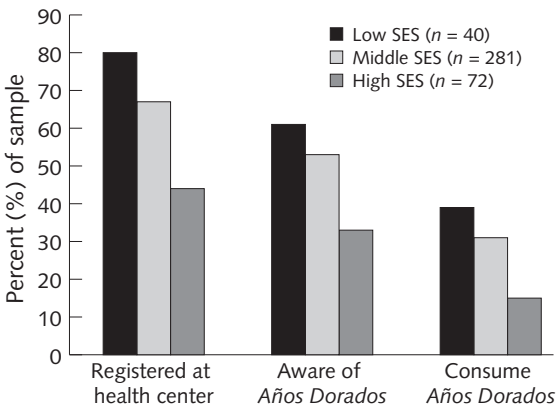

FIG. 1. Percentages of sample registered in health center, aware of availability of Años Dorados, and reporting the consumption of *Años Dorados*, according to socioeconomic status of *comuna* of residence in 2003 in Santiago, Chile. SES, socioeconomic status

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.

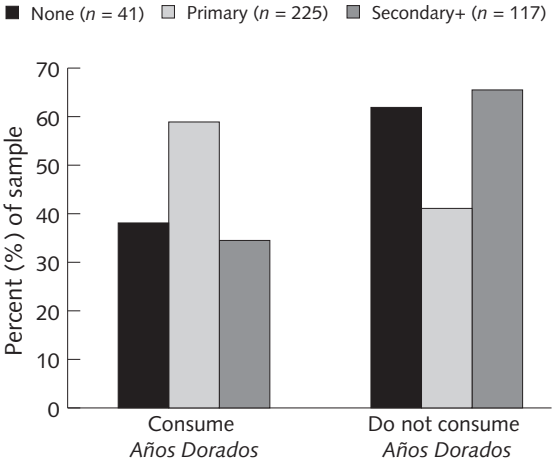

FIG. 2. Percentage of sample reporting consumption of *Años Dorados* in Santiago, Chile, in 2004, according to reported level of educational achievement in 1999-2000

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

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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.

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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

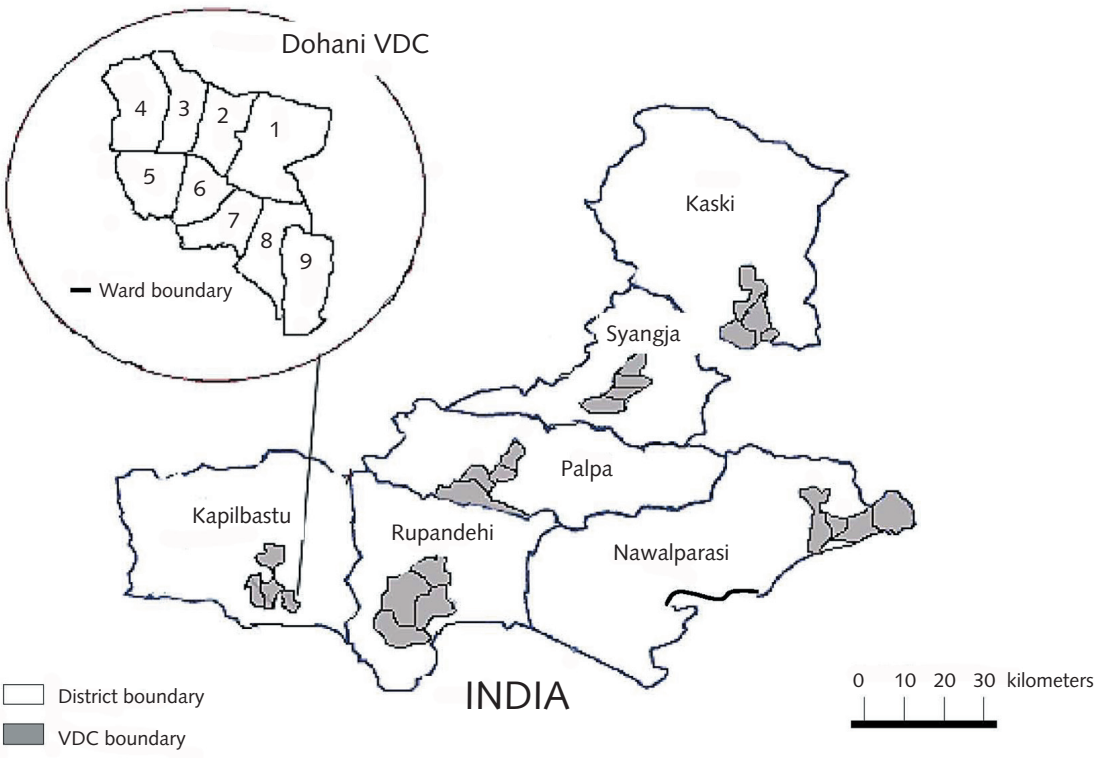

FIG. 1. Map of the Lumbini-Gandaki Zone, Nepal, where the MARD Project was responsible for implemented activities. Dohani Village Development Committee (VDC) in Kapilbastu District is highlighted to illustrate the division of VDCs into wards. Shaded areas are MARD VDCs

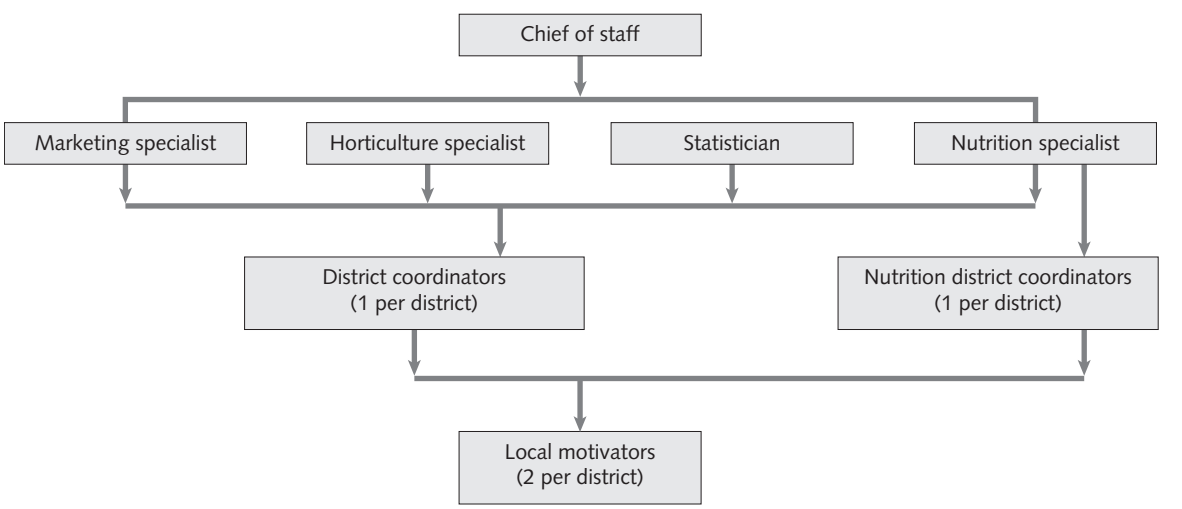

FIG. 2. Organization of the MARD Project

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 Horticul-

tural 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

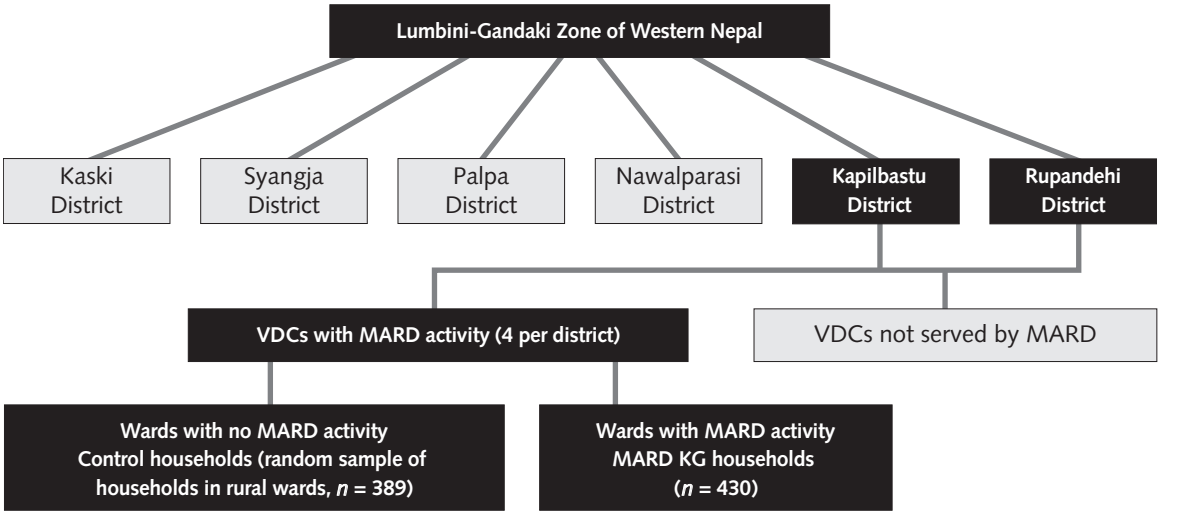

FIG. 3. Organization of household selection for survey. KG, kitchen garden; VDCs, Village Development Committees

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.

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.

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.

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

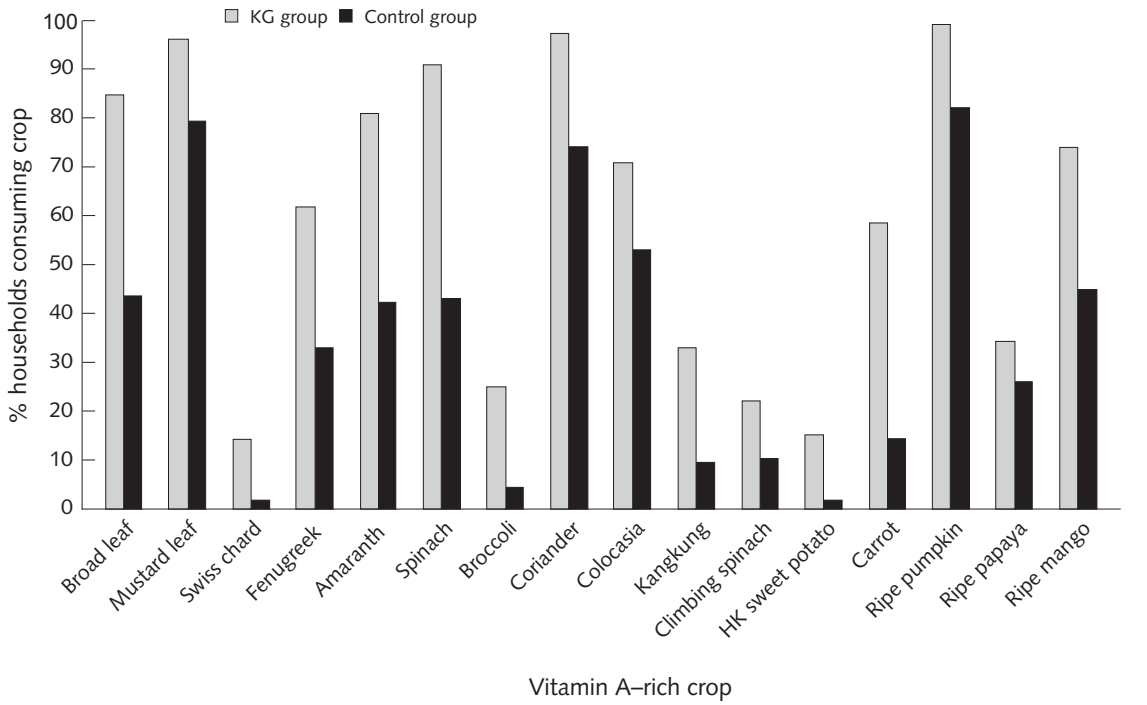

FIG. 4. Households with kitchen gardens (KG) reported consuming more household-produced micronutrient-rich fruits and vegetables promoted by the MARD Project than did control households ($p < .05$ for papaya; $p < .001$ for all other crops)

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.

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Stunted child–overweight mother pairs: Prevalence and association with economic development and urbanization

James L. Garrett and Marie T. Ruel

Abstract

This paper explores the prevalence of the coexistence of a stunted child and an overweight mother in the same household (SCOWT), a somewhat paradoxical phenomenon when found in the developing world. It tests whether this phenomenon is associated with a country's level of economic development and urbanization and, by implication, the nutrition transition. It then highlights policy directions for public nutrition. Data from 42 Demographic and Health Surveys in Africa, Asia, and Latin America were used. Stunting was defined as height-for-age < –2 SD of the reference population, and maternal overweight as a body-mass index > 25 kg/m^2. World Bank and United Nations figures were used for gross domestic product (GDP) per capita (an indicator of economic development) and for level of urbanization. Descriptive statistics were derived, and regression analysis was used to model the association between economic development, urbanization, and the prevalence of pairs of stunted children and overweight mothers. The prevalence of this phenomenon is generally below 10%, except in four countries, three of them in Latin America. The phenomenon is generally more prevalent in Latin America than in Africa, though not necessarily more prevalent in urban than in rural areas. The analysis finds that the phenomenon is associated with economic development, but not urbanization, and that it does differ between urban and rural areas and regions. The association with GDP per capita supports the hypothesis that SCOWT increases with economic development, up to a point. SCOWT appears to be most prevalent, as expected, in those countries in the midst of the nutrition transition. Recognizing this phenomenon is important for delineating strategies that respond to the differential needs of individuals within the household and do not just affect the household as a whole. This may become especially important with future economic development and, potentially, urbanization.

Key words: DHS (Demographic and Health Surveys), economic development, malnutrition, nutrition transition, overweight, stunting, urbanization

Introduction

In cruel and ironic contrast to the deprivation associated with poverty, diseases more often associated with excess, such as diabetes, obesity, and heart disease, have also emerged as serious concerns in many developing countries [1, 2]. These countries now face the worst of two worlds: millions of infants, young children, and adults suffer from hunger and undernutrition at the same time as other millions contend with overnutrition and its consequences.

Traditional developing-country diets consist largely of unprocessed foods, and most households struggle to get enough food for everyone to eat. Yet with increased economic development and urbanization, populations in many developing countries are now consuming more energy, more processed foods, including more refined grains, and foods higher in saturated fat, sugar, and salt. National food and nutrition policies that affect the relative prices of foods may also encourage such changes. In the Middle East, for instance, some governments subsidize staple items such as oil, sugar, and wheat. The relatively lower prices of these foods can lead to their overconsumption at the cost

The authors are affiliated with the Food Consumption and Nutrition Division, International Food Policy Research Institute, Washington, DC 20006 U.S.A.

Please address queries to the corresponding author: James L. Garrett, Research Fellow, Food Consumption and Nutrition Division, International Food Policy Research Institute, 2033 K Street, N.W., Washington, DC 20006, USA.; e-mail: j.garrett@cgiar.org.

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

of a more balanced diet. A decline in physical activity may accompany these dietary changes. City-dwellers, including rural migrants, take on more sedentary jobs, and firms and households adopt labor-saving technologies [3, 4]. Together these conditions are contributing to a rise in overweight and nutrition-related chronic diseases (NRCDs) among these populations [4, 5]. The situation appears especially acute in the middle-income nations of Latin America and the Near and Middle East [2, 6]. During this "nutrition transition," symptoms of under- and overnutrition logically coexist at the population level. Overnutrition emerges as a national problem, even as undernutrition remains high, with wealthier households exhibiting "diseases of affluence," including obesity, and poorer households exhibiting food insecurity and malnutrition.

The nutrition transition is often conceived of as a national phenomenon, a wave of change in diet, physical activity, and body composition patterns that a country goes through on the road to higher levels of economic development [4], but recent work indicates under- and overnutrition can also exist not only in the same population, but in the same household [3, 7]. As Popkin [5] notes, this is somewhat surprising, since in developing countries undernutrition is generally thought of as reflecting deprivation at the household level: lack of income, lack of food, poor sanitation, and low levels of education, among others. These factors affect all members of the household directly, or indirectly through their impact on care, feeding practices, and diet. Numerous economic studies confirm the association of undernutrition and food insecurity with low income in developing countries [8–14].

In the face of pan-household constraints (such as the very low household income found in many developing countries), it is not surprising that the nutritional status of household members is fairly well correlated. The joint probability of undernutrition for children and mothers in the same household, then, would not just occur as a simple function of respective prevalences. Using the data in this study, for example, and testing with a one-sided Fisher exact test of significance, we found associations with $p < .10$ between the prevalence of stunted children and of underweight mothers in 29 of the 42 countries. In 38 countries, using a two-sided Fisher exact test of significance, we found an association with $p < 0.10$ between the prevalence of stunted children and overweight mothers.

The coexistence of undernutrition and overweight among members of the same household thus represents a weakening of intrafamilial associations of nutritional status and raises questions about its cause and implications for programs and policies. One possibility is that in these households, pan-household constraints have become less severe. One might conceive of this situation occurring more often in more economically developed and more urbanized countries, with higher overall levels of household income and more widespread food availability. Individual-level and intrahousehold factors, such as food choices, caring behaviors, and individual diets, become relatively more important. The locus of the leading constraints to food insecurity and malnutrition may shift from the household to the individual level. In the case of overweight, the household may have reached a point where sufficient resources exist for at least some individuals to get "enough" food to eat, in terms of energy, even if it is of low quality. Some household members could remain undernourished due to deficiencies of energy and essential nutrients, and others become overweight from excess energy. A somewhat different possibility is that at these higher levels of economic development, energy is sufficient for both children and adults, but micronutrient intakes remain low, leading to stunting in children and overweight in adults.

In any case, the coexistence of under- and overnutrition in the same household has implications for food and nutrition programming. Many programs in developing countries implicitly assume that child undernutrition indicates household food insecurity. Programs then target more food or more income to households with malnourished children. Yet under- and overnutrition in the same household makes this sort of targeting less effective. In this case, food choices and distribution within the household may be more important factors than the household's overall food availability and level of resources. The challenge to public finances and to a public health system that must simultaneously address the causes of both under- and overnutrition in the population is difficult enough, but the presence of both inside the household complicates matters.

Objectives

This paper reports the prevalence of the phenomenon of under- and overweight members in the same household and investigates its relation to global factors associated with the nutrition transition, namely economic development and urbanization. The paper looks at a particular expression of under- and overnutrition, the occurrence of a stunted (undernourished) child in the same household as an overweight (overnourished) mother. We term this pairing of a stunted child and an overweight mother SCOWT. The paper will quantify the prevalence of SCOWT in a number of developing countries, explore the association of SCOWT with economic development and urbanization, and highlight policy directions for the public nutrition community.

Some studies have examined broad national trends of increasing levels of obesity or overweight in regions where child undernutrition continues to be a serious problem [2]. Others have looked at the coexistence of overweight and underweight among any member of

the same household in countries generally considered to be undergoing a nutrition transition [3, 15]. This study documents the coexistence within a household of childhood stunting and maternal overweight. It is the first to present data on the global prevalence of this phenomenon and on countries at higher and lower levels of economic development and urbanization. This allows for comparison of countries that are arguably farther along in the nutrition transition with those that have only barely started along this path.

The rationale for a focus on stunting rather than underweight or wasting as an indicator of child undernutrition is that stunting reflects the cumulative, long-term effects of the numerous insults experienced by children during their intrauterine and preschool years [16]. Programmatically, then, many researchers and development practitioners consider it indicative of long-term deprivations at the household level. Although the specific etiologies differ, the nature of stunting and BMI as indicators of longer-term nutritional status make it natural to pair them for this analysis.

As an ecological study, this paper does not seek to identify specific household- or individual-level determinants of undernutrition or overweight. However, it does explore whether SCOWT is associated with longer-term economic and social processes at the population level. In this study, we hypothesize that a higher prevalence of SCOWT is associated with higher levels of urbanization and economic development. We know diet, activity, and child-care patterns shift with urban living and with higher incomes, and so we expect to see higher levels of adult overweight and obesity. If not accompanied by similar rates of decline in stunting at the household level, we will see the emergence of these SCOWT pairs along with the rise in overweight that often signals the nutrition transition.

Methods

Data

To conduct this analysis, we used publicly available data sets from the Demographic and Health Surveys (DHS) for 42 countries (27 in Africa, 8 in Latin America, and 7 in Asia). The DHS are funded by the US Agency for International Development and coordinated by Macro International. Data collection is usually carried out in collaboration with country governments using population sampling frames. All data are nationally representative. The years of the data range from 1992 to 2001. Although predominantly from Africa, the data do come from all developing-country regions, so they provide at least some indication of the prevalence of the phenomenon around the world. These data sets are available from the DHS website (www.measuredhs.com).

We chose data sets that had anthropometric data for mothers and their children. Children 6 to 60 months old and their nonpregnant mothers aged 18 years or older were included in the analysis. In 29 of the datasets the maximum age of children was 60 months old; in the remaining 13 it was 36 months old. If a mother had more than one child in this age group, we selected one of the children randomly for analysis.

For children's nutritional status, we used height-for-age Z scores (HAZ). Stunting was defined as HAZ below –2 SD of the World Health Organization/National Center for Health Statistics/Centers for Disease Control (WHO/NCHS/CDC) reference standards [17]. Using the WHO guidelines, we considered mothers with a body-mass index (BMI) > 25kg/m^2 as overweight [18].

We used World Bank figures for Gross Domestic Product (GDP) per capita (in constant 1995 dollars) for the same years as the nutritional status data [19]. GDP per capita is the per capita value of final goods produced within the country and here serves as a proxy for a country's level of economic development. Use of Gross National Income (GNI) would have added net receipts of primary income from abroad, but was not available in constant-dollar per capita terms. GDP per capita calculated using purchasing power parity (PPP) rates, rather than exchange rates, might arguably be appropriate as well, but the comparability of estimates using PPP rates is subject to significant doubt and heated debate [20, 21]. We estimated the percentage of the population in urban areas in the year of the DHS using United Nations sources [22].

Statistical analysis

From these data we calculated the prevalences of stunted children, overweight mothers, and SCOWT pairs (as a percentage of total child-mother pairs) in each country. We used the Statistical Package for the Social Sciences (SPSS) for descriptive statistics.

Using STATA, we estimated a multivariate linear regression model to explore the independent association of the level of urbanization and economic development with SCOWT. It is important to note that this is a cross-country regression model. It is not an attempt to model the determinants of nutritional status at the household or individual level, nor to "explain" either stunting or BMI. This model provides a simple control to determine the association of national-level factors of urbanization and economic development (holding the other factor constant) with SCOWT. Initially squaring the urbanization and GDP per capita variables allowed for flexibility to account for possible nonlinear relationships.

We also developed and tested models that included interaction terms to see if these national-level factors exhibited any difference in their association with

SCOWT across regions or in urban and rural areas. Dummy variables were used to represent categorical variables for geographic regions (Asia, Africa, and Latin America) and urban-rural areas. Main effects were interacted with the urban dummy and the regional dummies, using a joint F-test to determine whether there were any significant differences of the main effects in urban versus rural areas, or in different regions. We considered coefficients with p values < .10 significant with regard to main effects and F-tests with p values < .10 significant for groups of interactions. The interactions of the main effects with the urban dummy revealed no significant differences. The interactions with regional dummies (Asia and Latin America, with Asia as the initial reference) revealed no significant difference between urban and rural Asia and rural Africa. Consequently, the final model excludes main-effect interactions with the urban dummy variable and includes only regional interactions for Africa (urban) and Latin America (urban and rural).

With 42 countries, using both rural and urban observations, we had a total of 84 observations. The relatively small number of observations means we must be careful in interpreting results because of the limited statistical power, particularly within the Asian and Latin American regions.

Results

Prevalence

Overweight is a serious problem in many developing countries, with prevalence appearing to be higher in higher-income and more urbanized countries (**table 1** and **figs. 1–3**) [2, 3]. The range of overweight mothers

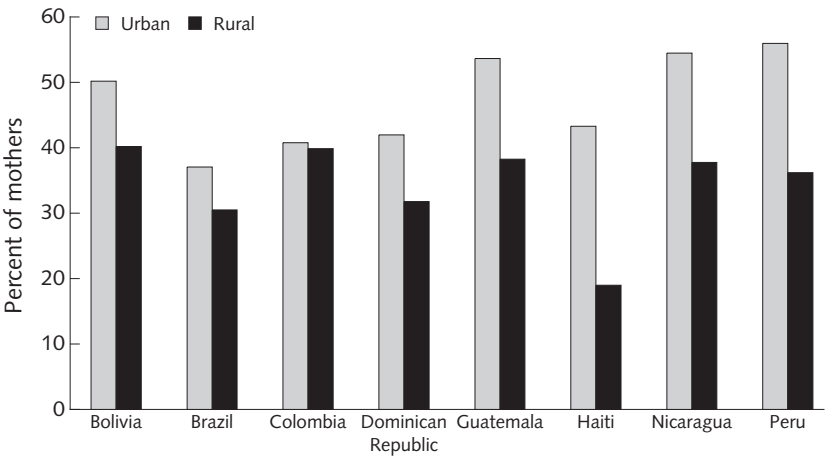

FIG. 1. Percentage of mothers overweight
Source: Demographic and Health Surveys from eight Latin American countries

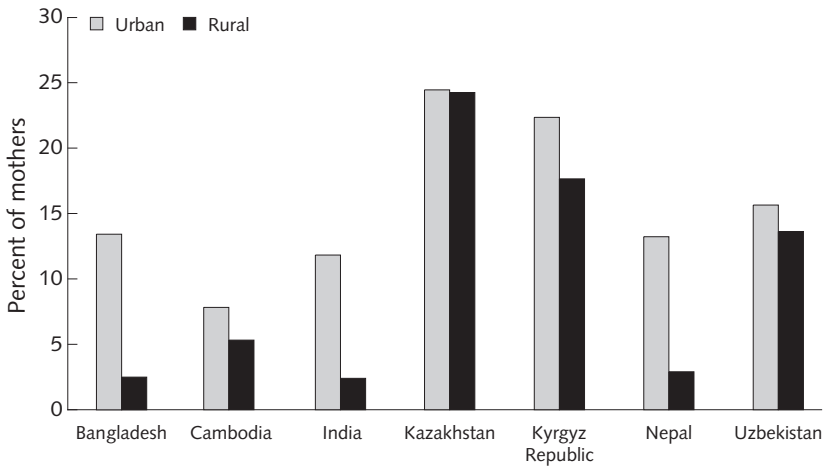

FIG. 2. Percentage of mothers overweight
Source: Demographic and Health Surveys from seven Asian countries

across African and Asian countries is particularly large. Among African countries in our sample, the percentage of overweight mothers ranges from a low of 2% in Ethiopia to a high of 71% in Egypt. In Asia, three of

TABLE 1. Descriptive statistics

Region and country	Year of survey	Children stunted (%)	Mothers overweight (%)	Children in SCOWT pairs (%)	Urban residence (%)	GDP per capita (1995 US$)
Africa						
Benin	2000	32.1	16.5	3.5	42.3	429
Burkina Faso	1999	41.9	5.8	1.9	16.7	272
Cameroon	1998	35.7	19.8	4.8	49.0	639
Central African Republic	1994	38.7	6.8	2.2	39.1	323
Chad	1996	46.0	5.2	1.8	22.2	212
Comoros	1996	37.2	19.6	5.6	30.4	453
Côte d'Ivoire	1998	25.4	17.3	2.5	43.6	870
Egypt	2000	19.4	70.8	12.4	42.1	1,217
Ethiopia	2000	55.1	2.0	0.9	14.9	116
Ghana	1998	27.2	16.1	2.7	43.9	390
Guinea	1999	30.4	13.4	2.9	32.6	613
Kenya	1998	34.8	11.9	2.4	35.9	340
Madagascar	1997	56.1	3.5	1.1	25.5	237
Malawi	2000	52.7	11.0	4.8	15.1	168
Mali	2001	43.9	13.8	4.0	30.2	303
Morocco	1992	25.0	32.8	5.8	48.4	1,293
Mozambique	1997	39.8	10.3	2.2	26.2	165
Namibia	1992	30.1	20.7	3.8	26.6	2,106
Niger	1998	47.5	7.6	2.1	20.6	220
Nigeria	1999	48.6	19.6	8.3	44.1	250
Rwanda	2000	45.5	13.5	5.6	13.6	267
Senegal	1992	26.2	17.3	2.5	40.0	547
Tanzania	1996	47.2	13.4	4.5	26.9	180
Togo	1998	24.8	11.5	1.8	33.4	344
Uganda	2000	40.7	11.2	3.1	12.0	339
Zambia	1996	46.4	12.8	4.5	37.3	409
Zimbabwe	1999	29.3	26.0	5.9	33.6	664
Asia						
Bangladesh	2000	46.8	4.4	1.0	23.2	373
Cambodia	2000	45.5	5.6	2.5	16.9	388
India	1998	50.1	4.6	1.2	27.7	430
Kazakhstan	1995	16.8	24.3	2.7	56.4	1,268
Kyrgyz Republic	1997	28.2	18.7	4.5	36.0	414
Nepal	2001	52.9	3.6	1.5	13.7	247
Uzbekistan	1996	33.2	14.2	5.5	38.4	585
Latin America						
Bolivia	1998	27.0	46.4	11.5	61.9	958
Brazil	1996	9.5	35.7	2.6	77.8	4,474
Colombia	2000	12.6	40.5	4.2	74.9	2,289
Dominican Republic	1996	8.9	38.0	2.2	56.6	1,726
Guatemala	2000	45.5	44.5	16.0	45.1	1,563
Haiti	2000	21.0	27.4	2.8	35.6	359
Nicaragua	2001	19.4	46.8	6.9	56.1	504
Peru	2000	24.4	47.8	9.6	72.8	2,334

GDP, Gross Domestic Product.

the seven countries are countries of the former Soviet Union (FSU). The percentages of overweight mothers in FSU countries are markedly higher than the figures for Bangladesh, Cambodia, India, and Nepal, where overweight mothers are practically nonexistent. In contrast, overweight mothers are quite prevalent in Latin America. In all Latin American countries, more than one-fourth of mothers are overweight, with figures ranging from 27% of mothers in Haiti to 48% in Peru.

Yet childhood stunting remains a serious problem in these countries as well, even in urban areas and even in countries with a high prevalence of overweight mothers (**table 1, figs. 4–6**). For instance, in Egypt and Peru, the

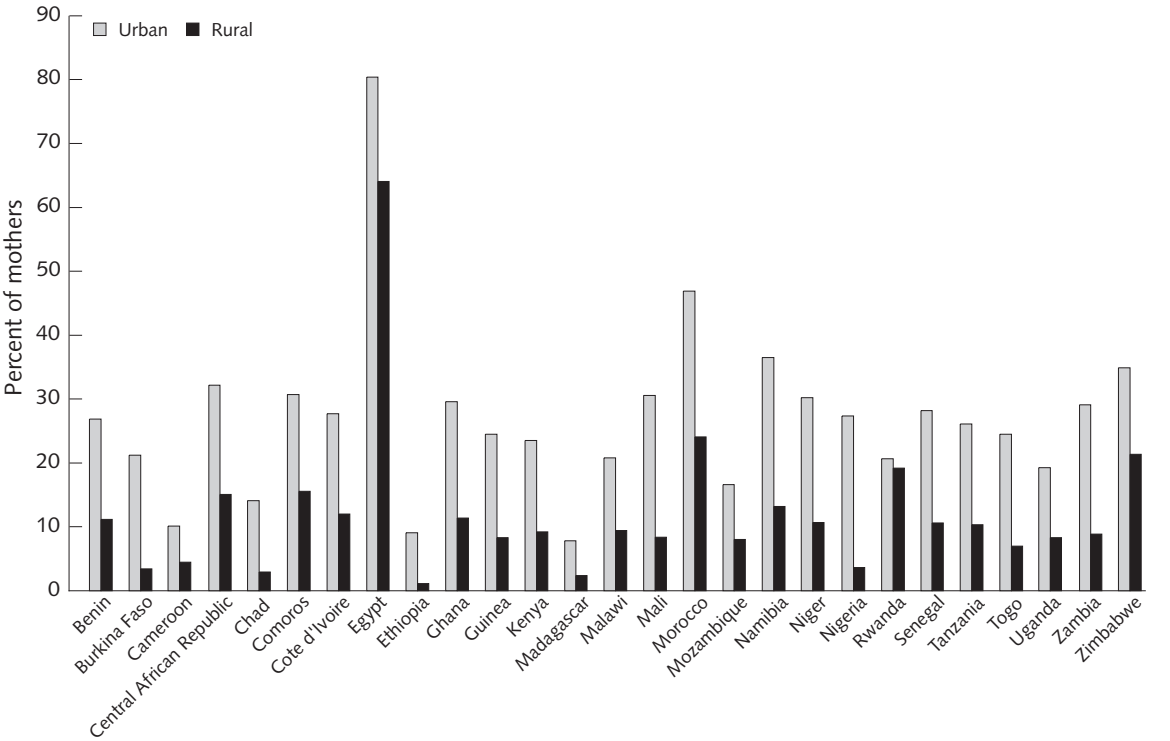

FIG. 3. Percentage of mothers overweight
Source: Demographic and Health Surveys from 27 African countries

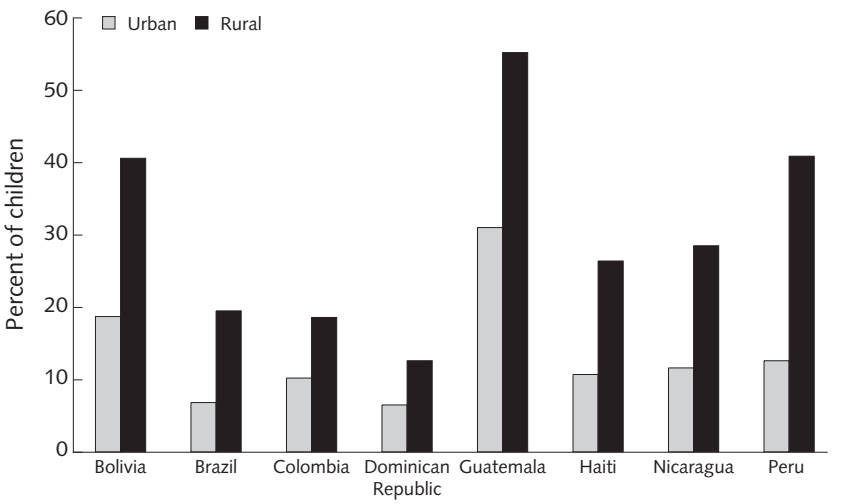

FIG. 4. Percentage of children stunted
Source: Demographic and Health Surveys from eight Latin American countries

countries with the highest prevalence of overweight mothers, 19% and 24%, respectively, of children 6 to 60 months old are stunted. More than 40% of preschoolers are stunted in many southern African countries and in Bangladesh, Cambodia, Guatemala, India, and Nepal. As documented previously, the prevalence of stunting is consistently higher in rural than in urban areas [23].

Overweight mothers and stunted children, of course, could occur in the population but not necessarily in the same household. **Figures 7, 8, and 9** present the prevalence of SCOWT pairs in the sample of countries studied. The prevalence of SCOWT is generally below 10%, except for four countries, of which three are in Latin America (Bolivia, Guatemala, and Peru). Egypt is the other country, with a prevalence of 12%. The level of SCOWT varies across countries and is related, as expected, to levels of both overweight and stunting. For instance, Bolivia and Guatemala have the highest prevalences of SCOWT in Latin America. Bolivia has

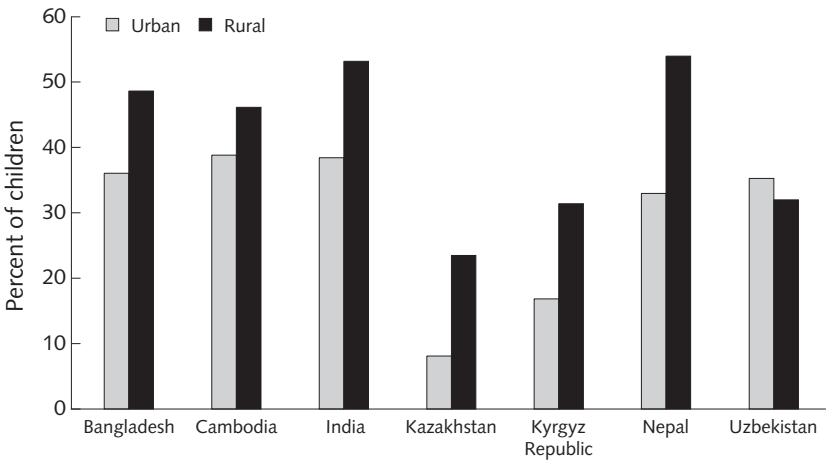

FIG. 5. Percentage of children stunted
Source: Demographic and Health Surveys from seven Asian countries

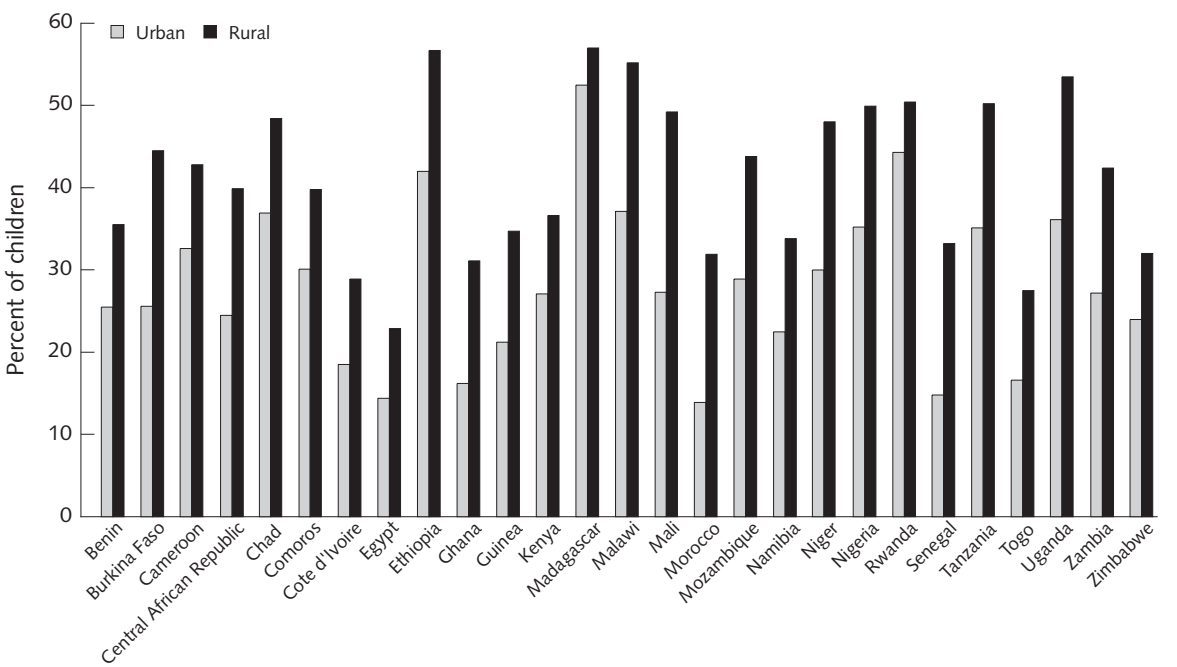

FIG. 6. Percentage of children stunted
Source: Demographic and Health Surveys from 27 African countries

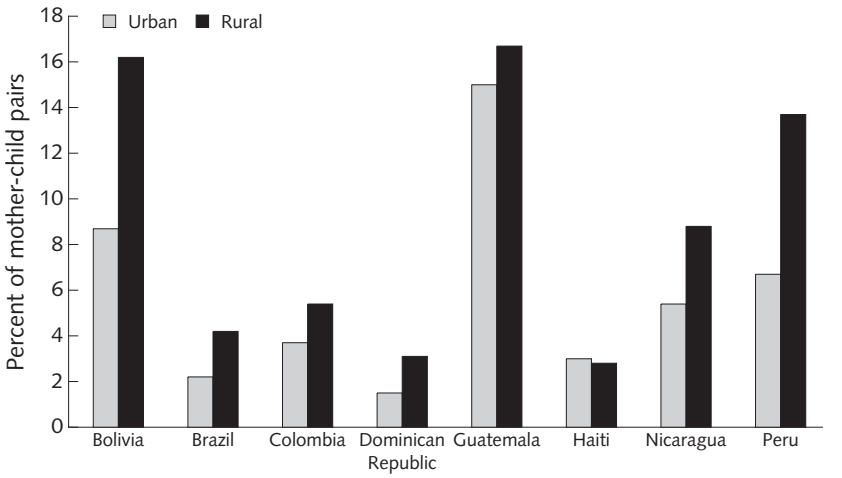

FIG. 7. Percentage of mother-child pairs consisting of stunted child and overweight mother.
Source: Demographic and Health Surveys from eight Latin American countries

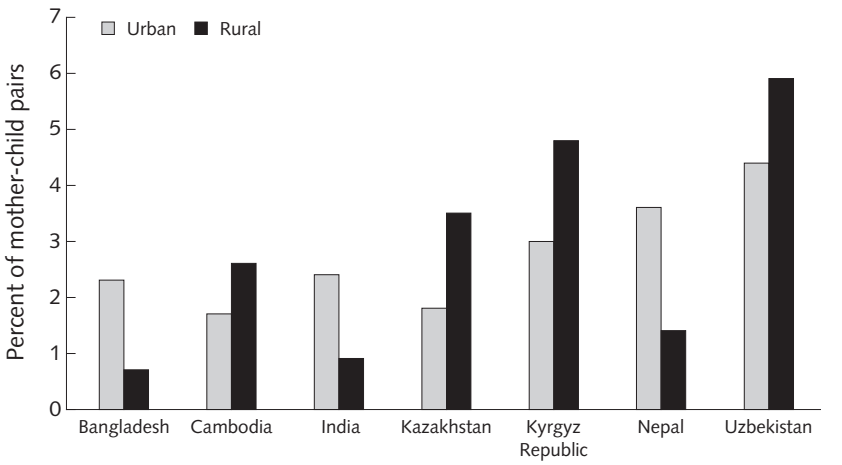

FIG. 8. Percentage of mother-child pairs consisting of stunted child and overweight mother
Source: Demographic and Health Surveys from seven Asian countries

the highest rate of overweight mothers in the region, at 47%, and Guatemala has the highest level of stunting, at 46%.

Surprisingly, SCOWT is not always more prevalent in urban than in rural areas (figs. 7–9). SCOWT, then, is not purely an urban phenomenon. This is because the prevalence of SCOWT is affected both by the rates of childhood stunting, which are consistently higher in rural than in urban areas, and by the prevalence of maternal overweight, which is almost always higher in urban areas.

In all Latin America countries except Haiti, the prevalence of SCOWT is actually higher in rural areas. In Asia, the prevalence of SCOWT is higher in the rural areas of four of seven countries, although prevalences are low in general and the urban-rural differences are small. In Africa, SCOWT prevalence is higher in rural areas in only three of 27 countries, but again, urban-rural differences are usually small. SCOWT primarily occurs in urban areas in Africa because fewer rural women than urban women are overweight (fig. 3), even though stunting levels are generally high in both rural and urban areas (fig. 6).

Association with economic development and urbanization

The regression results from the final model (**table 2**) show that economic development, as represented by GDP per capita, is associated with SCOWT but urbanization as such is not. Economic development is almost always positively associated with the prevalence of SCOWT across regions, though at a declining rate, as indicated by the negative coefficient on the squared term for GDP per capita. However, at GDP above US$1,691 per capita (a situation found in five of the

TABLE 2. Regression results[a,b]

Variable	Coefficient (standard error)	*p* value
Level of urbanization	.003 (0.032)	.94
GDP per capita	.003* (.001)	.01
GDP per capita squared	–8.87e–07* (2.79e–07)	.00
Africa dummy-urban	2.01* (1.36)	.01
Latin America dummy-rural	5.18* (1.43)	.00
Latin America dummy-urban	–3.09* (0.71)	.03
Intercept	1.87 (0.96)	.06

a. Dependent variable: SCOWT.
b. Adjusted $R^2 = 0.30$.
* Significant at $p < .10$. Asia-rural is the omitted dummy variable. Asia-urban and Africa-rural were not significantly different from Asia-rural and so are not included in this model. The coefficients on the Africa-urban and the Latin America-urban and -rural dummy variables are relative to Asia-rural.

study countries), the association becomes negative. This is consistent with our previous finding from analysis of the descriptive statistics that SCOWT depends on the prevalences of both stunting and overweight. At higher levels of economic development, stunting in particular may decline, and thus SCOWT may decline as well, resulting in an inverse U-shaped relationship between economic development and SCOWT.

The coefficients and levels of significance of some of the joint regional-urban dummy variables indicate that other factors within some regions, and urban and rural areas, are associated with SCOWT. The results indicate, however, that the associations with these factors do not differ between rural Africa and urban and rural areas in Asia. The associations in urban Africa and rural Latin America were significantly and positively different from these regional associations, whereas the association with urban Latin America was significantly and negatively different. We do not explore these regional relationships in more depth, but once again, when placing these areas along a continuum of economic development (and, logically, other related factors not included here but represented by these dummy variables), the results would suggest a relationship in the shape of an inverse U, with an increase from lowest levels (say, rural Africa) to higher levels (urban Africa and rural Latin America) and then a decrease at the highest levels (urban Latin America).

Discussion

This paper has attempted to identify how widespread the phenomenon of SCOWT is and the conditions under which SCOWT is more or less prevalent, in particular its association with features of the nutrition transition (economic development and urbanization). We find that SCOWT is not yet widespread, but in view of its higher prevalence in Latin America and its

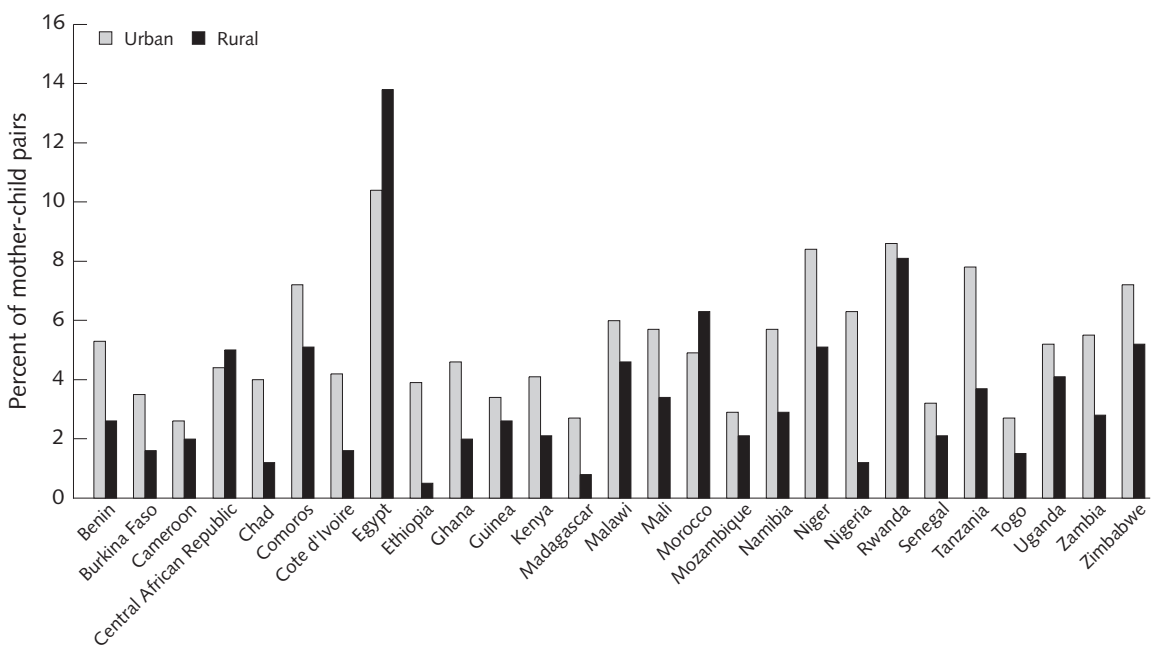

FIG. 9. Percentage of mother-child pairs consisting of stunted child and overweight mother
Source: Demographic and Health Surveys from 27 African countries

association with economic development, the findings suggest that policy makers need to be alert to it as countries advance economically and, potentially, enter the nutrition transition.

The prevalence of SCOWT in rural as well as urban areas confirms that SCOWT is not necessarily associated with living in an urban environment. Griffiths and Bentley [24] hint at this on the basis of data from the Indian state of Andhra Pradesh, where they found that socioeconomic status was a more important determinant of under- or overweight among women than was urban or rural residence. Popkin [25] also contends that it is not urban residence per se that causes overweight, but differences in lifestyle factors associated with an urban environment.

This may be because in countries with a higher level of economic development, both urban and rural areas are usually more integrated with economic markets. These rural areas may share lifestyle similarities with urban areas. Many farmers produce food not for subsistence or for their own consumption, but for cash. Mechanization of agricultural production reduces the level of physical activity. Rural towns are connected by roads and telecommunications with the rest of the world, just as are cities. The foods available to urban consumers are advertised and available in rural areas as well. The factors that lead to the nutrition transition and are associated with economic development [5] are apparent in rural as well as urban areas, and so the distinction becomes not that between urban and rural, or even between more and less urban, but between more and less developed (or industrialized).

Previous research on the coexistence of under- and overweight individuals in the same household [3, 7] indicated SCOWT could appear as part of a nutrition transition associated with increasing urbanization and economic development. Perhaps surprisingly, urbanization did not have a significant association with SCOWT in our study. But in fact, urbanization itself may not have any significant association with SCOWT beyond its correlation with economic development. Variation in the definition of "urban area" across countries could influence this result, as might collinearity of urbanization with GDP per capita. In further testing for collinearity, however, the coefficient on urbanization remained nonsignificant, even when GDP per capita terms were removed. On the other hand, the GDP per capita terms remained significant when the urbanization variable was omitted. The association with GDP per capita supports the hypothesis that SCOWT increases with economic development, up to a point. SCOWT appears to be most prevalent, as expected, roughly in those countries in the midst of the nutrition transition.

Of course, this ecological study explores only associations among SCOWT and social and economic processes at the population level. It does not investigate the exact causes of the emergence of under- and overnutrition in the same household, and findings cannot be applied to the individual or household level. For example, despite our finding that SCOWT is associated with higher levels of national GDP per capita, the poorest households within those countries could exhibit the highest levels of SCOWT. Still, the existence of SCOWT and its association with economic development encourages thinking about its causes and implications for policy, which can lead to some interesting hypotheses for future research to test.

Interpreting the SCOWT phenomenon as an expression of weakening intrafamilial associations of nutritional status, we pose a primary hypothesis that in the least developed countries, on average, household income tends to be a principal constraint on the household's ability to attain adequate nutrition for all household members. As incomes rise and countries become increasingly urbanized, *intra*household factors, including *individual* diets, activity, and disease patterns, emerge as relatively the most important determinants of nutritional status of household members. As one scenario, mothers could now be eating "enough" (or too many) calories, though possibly of low quality, while children still do not get "enough" of the right foods and suffer from other insults, such as disease, as well. In any case, generally speaking, household income is no longer the primary constraint to food security, and food security, as indicated by household caloric availability, is no longer the primary constraint to good nutrition.

Our hypothesis does find support in work of other researchers on developing societies. Monteiro et al. [15] argue that in less developed countries, undernutrition is highly dependent on food availability, so a high degree of intrafamilial association of nutritional status (say, underweight with underweight) should exist. In more developed countries, such as Brazil, where the problems of low income and lack of food are less widespread, undernutrition would be associated with specific diseases or individual characteristics. Intrafamilial association of nutritional status—of which SCOWT is one example—would be weaker in these higher-income developing countries.

The finding of Townsend et al. [26] that in the United States *low* income is associated with food insecurity and with overweight does not contradict this hypothesis. Partly this is a result of definitional differences. Townsend et al. [26] do not take "food insecurity" to mean calorie insufficiency, the indicator most commonly used in the developing-country context and what we mean here. Rather "food-insecure" women in the Townsend et al. [26] study eat enough, "but not always the foods the individual wants," and only "sometimes" do not get enough to eat. In fact, the authors exclude households that "often" do not get enough to eat, effectively excluding those households

more likely to be calorie insufficient. Among the few "severely food insecure" women in their sample (11 of 4,509), those who "often" do not get enough to eat, overweight is actually less prevalent, as expected.

Taken together as part of a global development continuum, these results suggest that the prevalence of overweight (or obesity) across income levels follows an inverted U-shape. Our own statistics show low prevalences of overweight mothers among the poorest nations. Monteiro et al. [27] looked at a country in the midst of the transition (Brazil) and found higher levels of obesity among the *higher*-income households of the *less* developed regions and among the *lower*-income households of the *more* developed regions. Likewise, Townsend et al. [26] found higher rates of overweight among lower-income households of a more developed country, the United States.

The emergence of a phenomenon such as SCOWT would also not be surprising, given that most research indicates that household members probably do not experience the changes in physical activity and diet that accompany the nutrition transition uniformly, leading to different individual outcomes [7, 28]. Indeed, differences in how infants and small children and adults experience the nutrition transition seem quite likely.

The process of economic development itself may also enhance the possibility of SCOWT. The so-called fetal origin hypothesis links fetal and early childhood nutrition to chronic disease risks later in life. The hypothesis is based on the premise that nutritional insults during critical periods of gestation and early infancy, followed by relative affluence, increase the risks of chronic diseases at adulthood [29–31]. Although most evidence to date links early malnutrition to the risk of diabetes, high blood pressure, and certain forms of cancers in adulthood, there is some indication of an association between childhood stunting and increased risk of obesity during adolescence and adulthood [32]. Thus, the prevalence of SCOWT, especially in those countries with historically high rates of childhood stunting that are now at higher levels of economic development, may be due to the fact that many children continue to experience stunting, while their stunted mothers are increasingly becoming obese as a result of increased household availability of food and energy.

On the other hand, other research supports the idea that a single factor, dietary quality, underlies the coexistence of under- and overnutrition in the same household [33]. If, as incomes increase, households address problems of hunger and energy insufficiency, dietary quality—the micronutrient content of the diet and its composition in terms of percentages of energy from saturated fats and refined sugars—may become the key nutritional constraint for both children and adults. Low dietary quality in children usually leads to inadequate micronutrient intake, which in turn causes micronutrient deficiencies and poor growth, health, and developmental outcomes. In adults, low-quality diets may result in micronutrient deficiencies and increase the risk of obesity because of the excessive amounts of energy, saturated fats, and refined sugars that these diets often contain. Poor dietary quality among energy-sufficient households may thus be related to SCOWT as well. Along these lines, overweight and obesity could exist among the stunted children in our SCOWT pairs, suggesting a broader role for micronutrient deficiencies as a cause and a lesser role for calorie insufficiency. Although recent research highlights the existence of an association between stunting and obesity in children in countries undergoing a nutrition transition [32, 34, 35], this does not appear to be a significant factor in our own sample. In only 4 of the 42 study countries were more than 5% of the stunted children overweight (> 2 SD of the WHO/NCHS/CDC reference standards).

Under either hypothesis, broadly speaking, improvements in feeding practices are called for. But in the case of an energy deficit, the most appropriate response would be changes in intrahousehold resource allocations, with more food for the child. In the case of micronutrient deficits, the quality of the diet should be improved with better, and not necessarily more, food.

Policy and program challenges

We began by noting that many would consider that in developing countries it would be likely for undernutrition to be common among members of the same household, or more generally, that nutritional status would be associated among household members. We took the prevalence of a specific example, SCOWT, where this was not the case.

The main point of the paper, however, was not to establish the statistical independence (or not) of the nutritional status of family members. For policy purposes more relevant is the fact that SCOWT is an important public nutrition phenomenon in some countries, and that these countries tend to be those with higher levels of economic development (in the context of developing-country regions). SCOWT thus poses a challenge for policymakers and programmers in developing and rapidly urbanizing countries. SCOWT is already a phenomenon that increases the complexity of nutrition and food-security interventions in Latin America. With increased economic development, SCOWT will probably emerge as a complicating factor in Asia and Africa as well.

Policy makers and programmers can no longer assume that those households with malnourished children are simply in need of "more food." They must tune their antipoverty and food and nutrition programs to a more complex reality. In higher-income developing countries, which tend to be more urbanized, policy

makers may need to emphasize changes in *individual* dietary and activity patterns and in caring and feeding behaviors, not only changes in general household access to food. They also need to address issues of dietary quality. In lower-income, and less urbanized, developing countries, however, policy makers may in fact need to continue paying attention to policies and programs that increase *household* food availability and access.

This analysis highlights the individual nature of nutritional status and food insecurity in transition countries. In these countries, policy makers and programmers must tailor policies and programs to deal with the conflicting demands of dietary excess and deprivation not only in the population, but also in the same household. The analysis reinforces Uauy and Kain's [36] concern that programmers must be careful when implementing feeding programs for children in countries in the "advanced stages of the transition," because lack of food may not be the primary constraint to good nutrition. It also casts doubt on the widespread, often informal, use of child nutritional status as an indicator of household-level food insecurity, especially in countries in transition.

To deal with the challenges of the nutrition transition, experiences in Brazil, China, and Finland suggest a number of elements of successful programs to improve diets and activity levels [37, 38]. Lessons from these programs suggest that interventions must involve a wide range of community actors, including health services and schools, homemakers' organizations, and community leaders, and encourage community ownership; build capacity among these community organizations; convey research-based messages on diet change, supported by health information and nutrition counseling; include the food industry as allies, and enact appropriate regulations, especially regarding labeling; and support appropriate amounts of physical exercise.

Although these programs encourage healthier eating and so are applicable to both undernourished (food-insecure) and overweight individuals, we have few examples of successful public nutrition programs that directly address the other part of the problem—undernutrition—at the same time. China's development of a diet-quality index and food guide pagoda is one of the few examples of a conceptual basis for policy-making that takes both deficiency and overconsumption into account [39].

We have few instances, however, of policies or programs that fully embrace the fact that they must simultaneously address over- and undernutrition. In general, even in transition countries, policy makers will still have to pursue policies to improve income, education, and health and hygiene behaviors. They must still ensure access to good health care, sanitation, and water for all. At the same time, they must develop strategies that respond to the differential needs of individuals within the household and do not affect just the household as a whole. The concrete recognition of this phenomenon could be an important step in delineating more effective and integrated strategies to do exactly that.

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Maternal employment and income affect dietary calorie adequacy in households in Sri Lanka

Ishara M. Rathnayake and Jeevika Weerahewa

Abstract

Nutritional deficiencies among children and mothers in lower-income households in Sri Lanka continue to be a major obstacle to the country's social and economic development. This study investigates the factors affecting dietary caloric adequacy in Sri Lanka, paying special attention to maternal income. An econometric analysis was performed using a household data set collected from a sample of 183 low-income households in the urban, rural, and estate sectors. The results showed that on average, mothers and children in the sample did not consume adequate levels of calories according to the recommendations of the Medical Research Institute of Sri Lanka. The mother's income and educational status, the number of children and adults in the family, and the ages, sexes, and birth orders of the children significantly influenced household and individual caloric adequacy. Specifically, the mother's income had a significant positive effect on the total caloric intake (CI) and caloric adequacy ratio (CAR) of the household, mother, and children and a significant negative effect on the relative caloric allocation (RCA) of the children. The results imply that when maternal employment generates extra income, the CIs of all individuals increase, yet the allocation of calories to the children of the household is reduced. Thus, provision of employment opportunities for mothers, along with adequate child-care facilities and nutritional educational programs, is a possible strategy to improve caloric adequacy among low-income households in Sri Lanka.

Key words: Dietary caloric inadequacy, gender, mother's income, Sri Lanka

Introduction

Poverty and malnutrition are two of the major developmental challenges facing Sri Lanka. Successive governments have identified the importance of a healthy and productive future generation for the economic and social development of the country, and have therefore placed much emphasis on improving the nutritional status of the people, especially children and mothers. Concurrent with poverty alleviation programs, governments have implemented special maternal and child nutrition improvement programs, as well as nutritional awareness programs through health clinics.

Despite such efforts, malnutrition has been continuously reported among mothers and children, especially those from low-income groups. Data on malnutrition among children and mothers, which is one of the results of dietary caloric inadequacy, show that the highest percentages of stunted (33.8%) and underweight (44.1%) children are recorded in the estate sector, followed by the rural and urban sectors. Furthermore, the highest percentage of malnourished mothers according to body mass index is recorded in the estate sector (58.6%), followed by the rural and urban sectors [1].

Household and individual income levels, sources of income, food habits, and household characteristics affect the food intake and thereby the dietary caloric adequacy of household members. Empirical evidence suggests that mothers play a significant role in determining the nutritional level of the household. Studies have shown that there are significant differences between the welfare benefits of income from men and that from women to the household, and the share of

The authors are affiliated with the Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Please address queries to the corresponding author**:** Jeevika Weerahewa, Senior Lecturer, Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka; e-mail: jeevikaw@pdn.ac.lk.

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income generated by mothers makes a significant contribution to the proportion of the household budget that is allocated to education and staples.* Further, studies have shown that women's educational levels and status within the household, the health environment, and the care received by children affect the nutritional status of the children [2, 3]. At present, women in Sri Lanka are involved in many economic activities. Women workers are dominant in the tea plantation and garment sectors and as expatriate workers in the Middle East. It is expected that with the increase in income level of women, their bargaining power in the allocation of household resources will tend to increase. Previous studies have found that poor women in the tea plantation sector of Sri Lanka earn higher incomes than poor women in other sectors and have better access to health-care facilities and specially designed maternal nutrition programs, yet the level of nutrition of mothers and children still remains low [4, 5].

Given this context, the main objective of this study is to assess the dietary caloric adequacy among low-income groups in Sri Lanka, placing special emphasis on maternal income. The specific objectives are to determine the dietary caloric adequacy at the household and individual levels (children and mothers), and the factors affecting caloric intake and caloric adequacy at the household and individual levels and caloric allocation among different individuals in the same household.

Past studies

Many socioeconomic studies have been conducted in Sri Lanka to examine the nutritional status of households and the factors affecting food intake. Tudawe [6], who conducted a study on the nutritional status of people in the Kirindi Oya Project area, found that differences in distribution of income influenced nutritional intake. Gunasekara [7] found that the status of malnutrition, as measured by anthropometric indices, depends on the employment status of the mother, the number of living children, the pregnancy status of the mother, and her level of education. However, only a few studies have considered the effect of the income level of mothers on dietary caloric adequacy. It was found that the maternal nutritional status of tea plantation workers, as measured by caloric intake and health status, was low compared with that of many other segments of Sri Lankan society. It was also found that nutritional status and health status are the results of specific income-related, work-related, historical, social, and structural factors [4, 5]. Rathnayake and Weerahewa [8], following Senaur et al. [9], conducted a study to identify the factors determining intrahousehold allocation of calories among the urban poor. They found that on average children and mothers do not consume adequate calories in comparison with fathers. They also found that the mother's income had a significant positive effect on her own relative caloric allocation and a significant negative effect on the children's relative caloric allocation.

Studies conducted in other countries have found that improvements in women's educational levels help to reduce the level of malnutrition among children [10]. Furthermore, according to Smith et al. [11], the nutritional status of children can be improved by improving women's social status or their power relative to men. Fabella [12] found that the food intake of children increased with increased family income, and that increase in the educational level of the mother helped to increase the food intake levels of girls.

Methods

The caloric intake (CI), caloric adequacy ratio (CAR), and relative caloric allocation (RCA) of households, fathers, mothers, and children were considered the indicators of dietary caloric adequacy in the analysis. CI was calculated from the food-consumption levels of different individuals and the caloric content of different food items. This measure does not consider the individual caloric requirements, and hence it does not give any clear picture of caloric adequacy. CAR was calculated by dividing the actual CI of an individual by the recommended daily allowance of calories for each individual. CAR measures the proportion of the recommended level of CI consumed by an individual family member. Age- and sex-specific values of daily levels of calories recommended by the Medical Research Institute (MRI) of Sri Lanka were used for the individuals in all the sectors [13]. The values of per capita daily allowance of calories recommended by the World Health Organization (WHO) and the MRI of Sri Lanka are the same. However, there are differences between the vitamin and iron daily recommendations suggested by WHO and MRI, which were not considered in this study. These daily caloric requirements are not adjusted for activity levels of the individuals, because of the unavailability of data for the urban and estate sectors. In order to find out the nature of food allocation among household members, RCA was used as the indicator. The RCA is the ratio between the CARs of individuals and the household CAR, and it measures the distribution of calories among individuals in relation to the total number of calories available to the household. It delineates not only nutritional adequacy but also the distribution of calories among household members.

Multiple regression analysis was performed to determine the factors affecting CI, CAR, and RCA. Separate

* Thomas D, Chen CL. Income shares and shares of income: empirical tests of models of resource allocation. University of California, Los Angeles, USA, Mimeo, 1993.

models were estimated for households, mothers and children. CI, CAR, and RCA were used as the dependent variables, and the income levels, educational levels, and ages of the mothers and fathers, the family size, and the sex, birth order, and ages of the children were considered as the independent variables. The mother's pregnancy or lactation status was also included where appropriate. If the mother was pregnant, a value of one was assigned, and zero was assigned otherwise. Similarly, if the mother was lactating, a value of one was assigned, and zero was assigned otherwise.

Caloric adequacy elasticities with respect to the mother's income level were also calculated for households and individuals in the total sample by using the following functional forms (note that Y is the indicator of caloric adequacy, X is the vector of independent variables with $j = 1,\ldots,n$ where $j = 1$ indicates mother's income):

(i) The linear model was specified as $Y_i = \alpha + \sum_{j=1}^{j=n} \beta_j X_{ij}$, and in this formation the caloric adequacy elasticity is given by $\eta_1 = \beta_1 \bar{X}_1 / \bar{Y}$.

(ii) The log-log model was specified as $\ln Y_i = \alpha + \sum_{j=1}^{j=n} \beta_j \ln X_{ij}$, and in this formation the caloric adequacy elasticity is given by $\eta_1 = \beta_1$.

(iii) The log-linear model was specified as $\ln Y_i = \alpha + \sum_{j=1}^{j=n} \beta_j X_{ij}$, and in this formation the caloric adequacy elasticity is given by $\eta_1 = \beta_1 \bar{X}_1$.

(iv) The linear-log model was specified as $Y_i = \alpha + \sum_{j=1}^{j=n} \beta_j \ln X_{ij}$, and in this formation the caloric adequacy elasticity is given by $\eta_1 = \beta_1 / \bar{Y}$.

The field surveys conducted by Rathnayake and Weerahewa [8] during December 2001–March 2002 and by Wijewantha* and Shyamalie** during December 2002–March 2003 at the Department of Agricultural Economics and Business Management, University of Peradeniya, Sri Lanka, were used to extract relevant data. When the survey was conducted, these researchers were students at the University of Peradeniya, and they gathered these data in order to complete their research work under the supervision of the second author of this paper. The relevant authorities of the University of Peradeniya gave approval to conduct the above studies. The sample included 260 low-income households, which consisted of 60 households from an urban area (Kandy Municipal Limits), 100 from a rural area (Polonnaruwa District), and 100 from an estate area (St. Coombs Estate in Thalawakale). In the urban area, data were collected from four purposely selected Gramasevaka divisions, since lower-income groups are concentrated in these areas. Those divisions were Suduhumpola, Deyyannewela, Bahirawakanda, and Mahayyawa. In the rural area, data were collected from five randomly selected Gramasevaka divisions: including Bandiwewa, Alikimbulawa, Katukaliyawa, Bogahadamana, and Yudaganawa. From this sample, households whose monthly income fell below Rs 1,206.04 (US$1 = Rs 94.95) per person and that consisted of a father, a mother, and their children (i.e., nuclear families) were selected for the analysis. A monthly income of Rs 1,206.04 per person was considered the poverty line.*** This limited the sample to 43, 60, and 80 households from the urban, rural, and estate areas, respectively.

The researchers used structured questionnaires to collect data on food consumption and household characteristics. The questionnaire was developed by the researchers themselves and was initially pretested on 20 households in the urban area. During the pretest, it was found that the main difficulties were collecting reliable data on household income levels and daily food-consumption levels by recall. As a remedy, a few indirect questions were included in the questionnaire to cross-check the responses. For example, in addition to monthly income levels, questions on monthly expenditure levels were also included. Furthermore, questions on individual food-consumption levels were more disaggregated. Separate pretests were conducted in the rural and estate sectors, and subsequent modifications were made for the questionnaire used in the urban sector. The first survey was carried out in the urban sector by the first author of this paper, and instructions were provided to others to carry out the other two surveys.

Individual food-consumption data for the previous 24-hour period for all family members were collected by the recall method. Data on meals and snacks eaten out of the home were also collected by the recall method. The family members were asked the amount of food they had consumed during the previous 24-hour period. The questions were directly asked of the

* Wijewantha V. An assessment of intra-household allocation of calories: A case study of rural poor in Polonnaruwa. Unpublished project report. Department of Agricultural Economics, University of Peradeniya, Peradeniya, Sri Lanka, 2003.

** Shyamalie HW. 2003. An assessment of intra-household allocation of calories: A case study of estate poor in Thalawakale. Unpublished report. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka, 2003.

*** Siddhisena KAP, Jayathilaka MDRK. Identification of the poor in Sri Lanka: Development of composite index and regional poverty lines. Colombo: Institute of Policy Studies, 2003.

mother (or if not, of a female adult) of the household, since food allocation is done mainly by mothers or by other female members of the household. The main limitations of the recall method for gathering food-consumption data are that the respondent cannot precisely recall food-consumption levels and that the day on which the interview is conducted may not be representative. Therefore, food-consumption data were collected on five randomly selected days within a period of one month by making personal visits to each household. The caloric content of each meal of each family member except infants was calculated from standard food-conversion tables. The main limitation of the questionnaire, apart from the difficulties associated with recall, is that it is lengthy, requiring approximately 40 minutes to be filled in by the interviewer.

Table 1 shows selected socioeconomic characteristics of the sample. As stated earlier, the data set gives information from 183 nuclear families. An average household consisted of approximately three adults and two children. On average, a family earned a monthly income of Rs 5,232.40, of which the contribution of the mother was Rs 1,435.50, far below the amount contributed by men. The average educational level of the mothers and fathers in the sample was six years.

Results

Table 2 shows the status of caloric adequacy among different individuals in different sectors. On average, the subjects had a CAR of less than 1, implying that the CI was inadequate. However, there were differences between different sectors and different individuals. All the individuals in the rural sector had CARs of less than one, whereas only the children in the estate sector had a CAR of less than one.

Regression analysis was performed to identify the determinants of CI, CAR, and RCA, focusing on mothers and children, since they were the individuals who did not consume adequate amounts of calories. In addition, the determinants of household CI and CAR were examined. A number of specifications were estimated to identify the determinants by including different types of independent variables and using various functional forms.

Linear models were found to be satisfactory for the CI of households and mothers, and a log-linear model was found to be satisfactory for children. **Table 3** presents the results of the analysis. The results clearly show that the mother's income has a significant positive effect on the CIs of the household, mother, and children. It was found that the income earned by fathers did not have a significant effect, although the coefficients have the expected positive sign. Among education variables included in the specifications, the mother's education had a positive and significant effect only on the mother's CI, suggesting that the number of years of formal education of the mother influences only her own CI. The results also indicate that when mothers are older, they tend to consume more calories and feed their children well. Among children, boys consume more calories than girls. Also, the elder children were fed better than the younger children, as revealed by the coefficient for birth order. Larger families, as measured by the number of adults and children, consume more calories.

Among the specifications tested to identify the determinants of CAR of households, mothers, and children, linear specification was found to be satisfactory for households and mothers and log-linear specification for children. The analysis clearly shows a positive relation between the mother's income and the CARs of the household, the mother, and the children (**table 4**). Contrary to the popular belief that education has a strong positive impact in alleviating caloric inadequacy, the higher the level of the mother's education, the lower the CAR of the children and the higher the CAR of the mother. The larger the family size, the lower is the household CAR, but the larger the number of adults, the higher is the CAR of the children. The latter result implies that such adults, i.e., elder children in the family, help in child-care activities. Among children,

TABLE 1. Socioeconomic characteristics of the sample

Independent variable	Level	Mean	SD
Age (yr)	Father	38.51	13.98
	Mother	36.20	11.78
	Children	9.87	4.58
Educational level (yr)	Father	6.43	3.68
	Mother	6.31	3.69
Income (Rs/month)[a]	Total	5,232.40	2,094.89
	Father	3,495.69	1,643.36
	Mother	1,435.50	1,806.17
Birth order	Child	2.15	1.12
Family size	Adults	2.57	0.94
	Children	1.96	1.23

a. US1$ = Rs 94.95.

TABLE 2. Caloric adequacy ratio (CAR) for children, mothers, fathers, and households in the different sectors

Group	Rural	Urban	Estate	Sri Lanka
Children	0.56 (n = 124)	0.77 (n = 66)	0.76 (n = 152)	0.69 (n = 342)
Mothers	0.77 (n = 60)	0.87 (n = 43)	1.06 (n = 80)	0.95 (n = 183)
Fathers	0.79 (n = 60)	1.04 (n = 43)	1.06 (n = 80)	0.96 (n = 183)
Households	0.69 (n = 60)	0.88 (n = 43)	0.97 (n = 80)	0.85 (n = 183)

TABLE 3. Regression results for caloric intake (CI)[a]

Variable	Category	Households	Mothers	Children
Intercept		321.84 (757.77)	900.47** (229.58)	6.40** (0.13)
Income	Mother	0.44** (0.08)	0.10** (0.02)	4.37E–05** (0.00)
	Father	0.01 (0.09)	0.72E–02 (0.02)	4.19E–06 (0.00)
Education	Mother	–53.95 (43.79)	33.10* (13.26)	–6.29E–03* (0.00)
	Father	7.38 (48.91)	–3.70 (14.81)	NA
Age	Mother	–13.72 (15.48)	10.10* (4.69)	8.26E–03* (0.00)
	Father	37.01** (12.34)	1.36 (3.73)	NA
	Child	NA	NA	3.85E–02** (0.00)
	Child's birth order	NA	NA	–7.01E–02** (0.02)
Family size	No. of children	1,039.26** (130.65)	25.19 (39.58)	1.88E–03 (0.02)
	No. of adults	1,574.94** (197.80)	–32.86 (59.92)	5.41E–02 (0.03)
Child's sex	(Male = 1, female = 0)	NA	NA	0.10** (0.03)
Other	Pregnancy (yes = 1, no = 0)	NA	NA	NA
	Lactation (yes = 1, no = 0)	NA	NA	NA
Statistical criteria	R^2	0.54	0.19	0.47
	No. of observations	183	183	342
	Functional form	Linear	Linear	Log-linear

NA, variables not included in the analysis.
a. Numbers in parentheses are standard errors.
*$p < .05$; **$p < .01$

TABLE 4. Regression results for caloric adequacy ratio (CAR)[a]

Variable	Level	Households	Mothers	Children
Intercept		1.11*** (0.08)	0.41*** (0.12)	–0.56*** (0.13)
Income	Mother	0.44E–04*** (0.95E–05)	0.56E–04*** (0.13E–04)	4.59E–05*** (0.00)
	Father	–0.91E–06 (0.11E–04)	–0.11E–05 (0.15E–04)	1.60E–07 (0.00)
Education	Mother	–0.70E–02 (0.51E–02)	0.01** (0.70E–02)	–8.53E–03* (0.00)
	Father	0.27E–02 (0.57E–02)	–0.30E–02 (0.78E–02)	NA
Age	Mother	–0.26E–02 (0.18E–02)	–0.73E–02*** (0.24E–02)	5.61E–03* (0.00)
	Father	0.26E–02* (0.14E–02)	0.13E–02 (0.19E–02)	NA
	Child	NA	NA	–4.49E–03 (0.00)
	Child's birth order	NA	NA	–7.08E–02*** (0.02)
Family size	No. of children	–0.08*** (0.01)	0.61E–02 (0.02)	–1.57E–02 (0.02)
	No. of adults	–0.05** (0.02)	–0.01 (0.03)	6.40E–02* (0.03)
Child's sex	(Male = 1, female = 0)	NA	NA	6.76E–02** (0.03)
Other	Pregnancy (yes = 1, no = 0)	NA	NA	–0.32*** (0.09)
	Lactation (yes = 1, no = 0)	NA	NA	–2.27E–02 (0.06)
Statistical criteria	R^2	0.21	0.23	0.20
	No. of observations	183	183	342
	Functional form	Linear	Linear	Log-linear

NA, variables not included in the analysis.
a. Numbers in parentheses are standard errors.
*$p < .10$; **$p < .05$; ***$p < .01$

the boys are better nourished than the girls, and elder children are better nourished than younger children. Further, when the mother is pregnant or lactating, calorie adequacy among children tends to be reduced.

Regression results for RCA are presented in **table 5**. Log-linear and linear specifications were found to be satisfactory for mothers and children, respectively. The results show that the mother's income has no significant effect on her own RCA but has a significant negative effect on the children's RCA. The results also imply that more-educated mothers allocate more calories to themselves than do less-educated mothers. Among children, male children get a fair allocation of food compared with female children, and elder children get a fair allocation compared with younger children in a family.

The above results very clearly indicate that extra income earned by mothers by engaging in employment has a significant impact on caloric adequacy. This aspect is highlighted in **table 6** by the use of caloric adequacy elasticities, which indicate that the CI and CAR of households, mothers, and children are increased by increased maternal income. Formal education is not sufficient to alleviate caloric inadequacy, and hence specifically targeted nutritional programs will be needed. Furthermore, as the conventional wisdom suggests, provision of adequate care is important in alleviating nutritional deficiencies.

Conclusions and policy implications

This study investigated the status of dietary caloric adequacy and assessed the impact of different characteristics of mothers on caloric adequacy in low-income households in Sri Lanka. CI, CAR, and RCA were used as indicators of caloric adequacy. The data were obtained from a survey conducted in an urban, a rural, and an estate area. Separate regression analyses were performed using CI, CAR, and RCA of mothers and children and CI and CAR for households as depend-

TABLE 6. Caloric intake (CI), caloric adequacy ratio (CAR), and relative caloric allocation (RCA) elasticities with respect to mother's income[a]

Level	Measure	Elasticity
Household	CI	0.08*
	CAR	0.67*
Mother	CI	0.08*
	CAR	0.81*
	RCA	0.14
Children	CI	0.05*
	CAR	0.05*
	RCA	–0.03*

a. For calculation of elasticities, the mean income level of the mothers was considered at Rs 1,435.50 (US$1 = Rs 94.95).
*$p < .01$

TABLE 5. Regression results for relative caloric allocation (RCA)[a]

Variable	Level	Mothers	Children
Intercept		–0.16* (0.08)	0.73*** (0.08)
Income	Mother	0.11E–04 (0.77E–05)	–2.34E–05*** (0.00)
	Father	–0.10E–04 (0.92E–05)	–6.12E–06 (0.00)
Education	Mother	0.92E–02** (0.43E–02)	–4.61E–03 (0.00)
	Father	–0.01*** (0.47E–02)	7.18E–03** (0.00)
Age	Mother	–0.10E–03 (0.19E–02)	–6.57E–04 (0.00)
	Father	–0.19E–03 (0.12E–02)	NA
	Child	NA	1.06E–02*** (0.00)
	Child's birth order	NA	–2.94E–02** (0.01)
Family size	No. of children	0.08*** (0.01)	2.88E–02** (0.01)
	No. of adults	0.06** (0.01)	1.78E–02 (0.02)
Child's sex	(Male = 1, female = 0)	NA	8.24E–02*** (0.02)
Other	Pregnancy (yes = 1, no = 0)	NA	NA
	Lactation (yes = 1, no = 0)	NA	NA
Statistical criteria	R^2	0.29	0.18
	No. of observations	171	342
	Functional form	Log-linear	Linear

NA, variables not included in the analysis
a. Numbers in parentheses are standard errors.
*$p < .10$; **$p < .05$; ***$p < .01$

ent variables. Household characteristics, including the income, education, and age of the mothers and fathers, the age, gender, and birth order of the children, and family size, were considered as independent variables.

The mean CARs of households, mothers, and children were 0.85, 0.95, and 0.69, respectively, indicating that on average, households, mothers, and children did not consume adequate levels of calories as compared with the daily recommended levels. The results of the regression analysis show that the income level of the mother has a statistically significant positive impact on the CI and CAR of the households, mothers themselves, and children. This clearly implies that the higher the income of the mother, the higher the CI and the lower the calorie inadequacies of all individuals in the household. The regression results also indicate that the mother's income had a statistically significant negative effect on children's RCA. This result does not indicate that the nutritional status of the children is worsened when the mother works, because the actual CI and CAR of the children increase when their mother works. This phenomenon could be due to the fact that mothers do not have adequate time to carry out the allocation of food when they are employed. Furthermore, the results showed that the mother's educational level, as measured by her years of formal education, did not have a significant positive effect on caloric adequacies. Rather, the children's CAR increased as the number of adults in the household increased, a result implying that the adults were providing more care to the children.

The findings of this study have a number of policy implications. They suggest that significant improvements in the dietary caloric adequacy of children can be achieved by improving the level of income of mothers in low-income households in Sri Lanka. However, the results indicate that increasing mothers' incomes alone is not an effective strategy to improve the nutritional status of children, since the increase in mothers' incomes is associated with a reduction in the relative allocation of calories to children. The study emphasizes the importance of providing child-care facilities for working mothers. Furthermore, it recommends investments in targeted nutritional education programs, since formal education, as measured by years of schooling, does not seem to contribute to the alleviation of caloric inadequacies.

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Short Communication

The effect of family structure on a sample of malnourished urban Nigerian children

Lola Adekunle

Commentary

This article is of interest because it provides a different lens through which to view the role that family structure plays in the nutritional status of children. In addition to looking at socioeconomic factors, such as parental employment status, the author also looked at the mother's seniority among the wives in polygamous households. It was found that children of the first wife were more likely to be malnourished, supporting the author's assertion that these wives and their children are more likely to be neglected. At the same time, the study failed to support the notion that higher birth order is related to malnourishment. This finding is of interest because it contradicts many other studies that have found a link between higher parity (or increasing birth order) and risk of being malnourished. However, the study did not examine the total number of children in these households, raising the possibility that this could have been a significant factor. Finally, this study will be interesting to those who are interested in gender differences in care-seeking behaviors. The fact that almost two-thirds of the children in this hospital-based study were males raises the possibility that parents were less likely to seek treatment for female children, as has been documented in Southeast Asia.

Jerry Sternin, Jennifer Olsen
Positive Deviance Initiative
Boston, MA, USA 02111

The author is affiliated with the Department of Epidemiology, Biostatistics and Environmental Health, College of Medicine, University of Ibadan, Nigeria.

Please address queries to the author at P.O. Box 9583, U.I. Post Office, Ibadan, Nigeria; e-mail: emseh@skannet.com.

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Abstract

This study focused on the role of family structure in 458 malnourished children under five years of age clinically diagnosed with protein-energy malnutrition (PEM), kwashiorkor, and marasmus. The majority of these children were of higher birth order (3rd child and higher): 63.2% based on the mother's parity and 56.4% based on the father's parity. More than half (54.8%) of the malnourished children's mothers were the first wives of their respective husbands. About 43.9% of the children's fathers were urban danfo *(public minibus transport) drivers. Half (51.5%) of the mothers who claimed to be single opted into single status and were mostly from polygamous households, but 87.6% of the children were from polygamous families, of which 18.6% of the mothers had divorced. Only 27.7% of the children lived with both parents; 40.4% lived with their grandparents, and 37.8% were the financial responsibility of their grandparents. We observed an association between children treated for malnutrition and father's occupation, parents' marital status, mothers' seniority among other wives, and source of financial responsibility for the children.*

Key words: Family structure, malnutrition, risk factors

Introduction

An estimated 85% of children born in the world live in developing countries. Of these children, 10% die before they reach the age of one year, and 4% die of malnutrition and other diseases before they are five years old [1]. The most affected are usually the children of illiterate parents in low socioeconomic brackets who have low purchasing power in the economy. The effect of malnutrition on the susceptibility of these children to a wide range of diseases has long been a major research concern. Several observations have shown that the nutritional status of children prior to the onset of serious infections has a large effect on how well they withstand the infection [2–4]. Several studies have

shown that children who are already malnourished suffered severe complications of measles and have a higher mortality rate than adequately nourished children with measles [5–10].

Children in low socioeconomic groups commonly suffer from inadequate nutrition [11,12]. The economic and political situation in Nigeria probably has increased stress on family structure. The purpose of this study was to assess the effect of conditions that might be associated with malnutrition. There is little doubt that family structure and social conditions constitute a major influence on child nutrition, but there is little or no information on the role of family structure, and the stresses on it, in malnutrition.

Methods

This investigation was conducted in Ibadan, the capital of Oyo State in Nigeria. The sampling procedure involved the consecutive selection of 458 children under five years of age who were hospitalized for severe malnutrition and received treatment at three major hospitals: University College Hospital, Adeoyo Hospital, and Oluyoro Catholic Hospital. The aim was to assess the family structure and other sociodemographic characteristics of the malnourished children's families. Each child was automatically selected into the sample based on admission for malnutrition. All the families selected voluntarily participated in the study, which was approved by the University institutional review board.

Detailed family histories, as well as socioeconomic and demographic characteristics of the parents of the children, were obtained by structured questionnaires and interviews; in addition, information regarding family stability, potential stressors experienced by the family, and family social conditions was recorded.

Results

The demographic characteristics of the 458 malnourished children were as follows: 55.7% were male and 44.3% were female; 41.3% were two or three years old; 15.5% were one year old or younger; 34.5% were four

TABLE 1. Demographic characteristics of the malnourished children (n = 458)

Characteristics	No. (%)	Characteristics	No. (%)
Sex		Mother's marital status	
Male	255 (55.7)	Single	236 (51.5)
Female	203 (44.3)	Married	107 (23.4)
Age (yr)		Separated/divorced	85 (18.6)
≤ 1	71 (15.5)	Deceased	30 (6.6)
2–3	189 (41.3)	Family structure	
4–5	158 (34.5)	Monogamous	57 (12.4)
≥5	40 (8.7)	Polygamous[a]	401 (87.6)
Birth order based on mother		Mother's seniority among wives	
1	83 (18.1)	1	251 (54.8)
2	92 (20.1)	2	90 (19.7)
3	88 (19.2)	3	30 (6.6)
4	58 (12.7)	4	87 (18.9)
≥5	137 (29.9)	Financial responsibility for child	
Birth order based on father		Both parents	71 (15.5)
1	96 (20.9)	Mother only	143 (31.2)
2	104 (22.7)	Father only	55 (12.1)
3	134 (29.3)	Grandparents	173 (37.8)
4	65 (14.2)	Other relatives	16 (3.5)
≥5	59 (12.9)	Child's living arrangement	
Father's occupation		With both parents	127 (27.7)
Civil servant/clerk	30 (6.6)	With mother only	85 (18.6)
Skilled worker (e.g., artisan)	69 (15.1)	With father only	42 (9.2)
Semiskilled worker (e.g., driver)	201 (43.9)	With grandparents	185 (40.4)
Unskilled worker	114 (24.9)	With other relatives	19 (4.1)
Unemployed	44 (9.6)		

a. The majority of women who claimed to be single were from polygamous households. They actually opted out of the marriage to remain single for lack of financial support from their spouses.

or five years old; and 8.7% were five years old or older (**table 1**).

The family structures break down as follows: 43.9% of the children belonged to families with fathers who held semiskilled jobs, mainly as urban *danfo* drivers; 24.9% belonged to families whose fathers were employed as unskilled laborers, such as in farming or petty trading; 9.6% of the fathers were unemployed; 15.1% were artisans; and 6.6% were civil servants/salary earners.

Of the 107 mothers who were married, 54.8% were the first wives of their husbands, 19.7% were second wives, 18.9% were fourth wives, and 6.6% were third wives. A little more than half (51.5%) of the mothers were single parents, 23.4% were married, and 18.6% were divorced, and 6.6% were deceased.

The majority of the children (87.6%) were from polygamous families, and only 12.4% were from monogamous families; 40.4% of the children lived with their grandparents, 27.7% with both parents, 18.6% with their mothers alone, 9.2% with their fathers alone, and the remaining 4.1% with other relatives. Only 15.5% of these children were being financially supported by both parents; 37.8% were supported by their grandparents, 31.2% by their mothers alone, 12.1% by their fathers alone, and the remaining 3.5% by other relatives.

Over 50% of the children were of higher birth order (3rd position and higher): 61.8% with respect to their mother and 56.4% with respect to their father. Of the mothers of the 458 malnourished children, 38% were between 20 and 29 years of age, 26.2% were between 30 and 39 years of age, 22.7% were under 20 years of age, and 13.1% were 40 years old or older. Of the mothers, 41.7% had primary education, 36.5% had only a Quranic education, 19.4% were illiterate, and only 2.4% had postprimary education. Half of the mothers (50.4%) were traders, 35.2% earned salaries, 12.9% were housewives, and 1.5% were students.

The prevalence of malnutrition was strongly related to the father's occupation, the mother's seniority among other wives, the mother's parity, and the child's living pattern (where the child lived and with whom) ($\chi^2 = 0.791$, 0.681, 0.771, and 0.613, respectively).

Discussion

There is little doubt that parental occupation, especially the father's employment status and ability to take responsibility for his family, plays a major role in child malnutrition [13, 14]. In this study, about half of the malnourished children belonged to families in which the fathers were semiskilled or unemployed. About half of the mothers were petty traders with low means of livelihood.

Other risk factors for malnutrition were the social conditions of the family, the living pattern of the children (where the children lived and with whom), the level of economic cooperation among the parents, and the level of financial stress experienced by the family. One of the most distinguishing features of the family as a subject of social interest is its importance as the basic unit of social life. Several studies have shown that the economic strength of a family, especially the father's occupational status, is highly correlated with family health [6, 9, 10, 15].

Although economic strength is no doubt important, it is apparent from this study that the level of interpersonal relationship that existed between the husband and wife, i.e., economic and financial cooperation for proper care of the children, was far more important. Only a few of the children belonged to families that included such cooperation. Interestingly, the majority of the mothers in this study were first wives. In a strictly traditional home, it is not uncommon for the husband to neglect, emotionally and financially, the first wife and her children. Simple analysis of the correlation coefficient showed that father's occupation, mother's seniority among other wives, mother's parity, and child's living pattern were major factors in the child's malnutrition. Only 15% of the children were financially supported by both parents and only 12% by their fathers; 38.7% were supported by their grandparents, while 30% of the mothers stated that they were solely responsible for their children, without any financial support from their husbands.

We did not have a control group in this study so our observations in the study group cannot be compared with a group similar except for presence of malnutrition. However, our observation of these families with severely malnourished children indicate that full family support, especially from fathers, is an important factor in a child's nutritional status.

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Letter to the Editor

In response to Gargari et al., "Prevalence of overweight and obesity among high-school girls in Tabriz, Iran, in 2001"

To the Editor:

I would like to congratulate Dr. Gargari on the work he has done on assessing the prevalence of overweight and obesity among high-school girls in Tabriz, Iran, [1]. This will undoubtedly contribute to the pool of much-needed data on obesity in the Asia region. However, I would like to make some comments about the methodology the authors adopted during the analysis of the data.

1. Why were NHANES I percentiles used when body-mass index (BMI)-for-age percentile charts from NHANES III were available online at the time of this study? [2]
2. The International Obesity Task Force (IOTF) cutoff values given for female adolescents are confusing. According to the published IOTF cutoff values, [3] the reference BMI cutoffs were not given as a range for a specific age range, but as a specific cutoff value for each age. It is true that IOTF published the BMI cutoffs for every six-month age group from 2 to 18 years. However, for a child whose age falls between an age group for which cut off values have been given (e.g., 14 years and 9 months, or 9.75 years) the BMI cutoff for overweight or obesity should be calculated by linear extrapolation.

   The BMI ranges that are given for overweight are likewise confusing. For example, the BMI range for overweight among 14- to 14.9-year-old girls was given as 23.66 to 28.87, but the two figures are the BMI cutoffs for overweight and obesity, respectively, in 14.5-year-old girls. If I were to determine the state of obesity/overweight in a girl 14 years and 11 months old with a BMI of 28.9, would this child be classified as obese? Not really, since the cutoff would be 28.87 + (29.11–28.87/6 months × 5 months) = 29.07. So this child is not obese but only overweight. Therefore, if this correct technique were used, I am sure the prevalence would change.
3. When IOTF overweight and obesity cutoffs are compared with the 85th and 95th percentiles, respectively, of the NCHS/CDC 2000 BMI-for-age charts, the 95th percentile of BMI-for-age is lower than the age-matched IOTF BMI cutoff for 14- to 16.9-year-old girls. Therefore, I believe that the number of children diagnosed as obese according to IOTF should be lower than the number of children diagnosed as obese according to the NCHS/CDC 2000 charts for the age group from 14 to 16.9 years.
4. Finally, please clarify where the underweight definitions were drawn from. To the best of my knowledge, the best references for definition would be the WHO Technical Report on Physical Status: The use and interpretation of anthropometry [4]**.** Underweight is a descriptive term based on weight-for-age parameters, and this report dismisses the use of weight-for-age in adolescents (page 272, paragraph 3). The descriptive terms related to BMI-for-age are thinness, overweight, and obesity (page 271, table 29). Thinness is defined as BMI-for-age < 5th percentile. Therefore, I think that definition should be used universally in defining thinness or underweight.

Dr. Pujitha Wickramasinghe
Department of Paediatrics
Faculty of Medicine
University of Colombo
Sri Lanka
E-mail: pujithaw@mail.ewisl.net

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Author's response

To the Editor:

I thank Dr. Wickramasinghe for his thoughtful remarks on our paper on overweight and obesity in high-school girls in Tabriz [1]. The authors' responses appear below.

1. We used two criteria.
   - » One is the BMI cutoffs of Must et al. [2], which are based on the NHANES I study. These cutoffs have been introduced by the World Health Organization/National Center for Health Statistics (WHO/NCHS) for international use. A WHO expert committee recommended BMI at or above the 85th percentile for international use to classify adolescents as overweight [3], whereas the National Center for Health Statistics/Centers for Disease Control and Prevention (NCHS/CDC) BMI cutoffs are based on the 2000 CDC BMI-for-age-growth charts for the United States and thus are country-specific. I do not think that these cutoffs have been introduced by WHO for international use. In this set, based on current recommendations of expert committees, children with BMI values at or above the 95th percentile of the sex-specific BMI growth charts are categorized as overweight [4].
   - » The other is the IOTF [5] sex- and age-specific BMI cutoffs. These were developed on the basis of data from many nations, including Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. They are derived from sex-specific curves that pass through a BMI of 25 and 30 by age 18 years for overweight and obesity, respectively.
2. We used the midyear values (for example, 14.5-year BMI values for the 14- to 15-year age group) for definitions of overweight and obesity. If we want to define a person as overweight or obese in the clinical setting, we need to linearly interpolate BMI cutoffs to the subject's exact age, whereas for epidemiologic use, with age groups one year in width, the cutoff point at the midyear value will give an essentially unbiased estimate of the prevalence, as Cole et al. [5] have discussed.
   - » According to table 4 in Cole et al. [5], the IOTF BMI cutoffs that correspond to BMI = 25 kg/m^2 in adults for the middle of the female age groups 14–15, 15–16, 16–17, and 17–18 years are 23.66, 24.17, 24.54, and 24.85 years, respectively.
   - » According to table 4 in Cole et al. [5], the IOTF BMI cutoffs that correspond to BMI = 30 kg/m^2 in adults for the middle of the female age groups 14–15, 15–16, 16–17, and 17–18 years are 28.87, 29.29, 29.56, and 29.84, respectively.
   - » Therefore, we considered BMI values of 23.66–28.87, 24.17–29.29, 24.54–29.56, and 24.85–29.84 to indicate overweight, and BMI values of ≥ 28.87, ≥ 29.29, ≥ 29.56, and ≥ 29.84 to indicate obesity for the above respective age groups.
3. We did not use NCHS/CDC BMI-for-age cutoffs.
   - » The BMI cutoffs have been widely used to define childhood and adolescent underweight, and they were also recommended for international use for adolescents aged 10 to 19 years by a WHO expert committee [3]. In many studies, they have been used for the definition of underweight [6-10], although some studies have used BMI-for-age < 20th percentile, some have used BMI-for-age < 15th percentile, and some have used BMI-for-age < 5th percentile for the definition of underweight.
   - » The CDC has used BMI cutoffs for the definition of underweight in children and teenagers [11]. The CDC has defined underweight and overweight as follows:

Underweight	BMI-for-age < 5th percentile
At risk of overweight	BMI-for-age 85th percentile to < 95th percentile
Overweight	BMI-for-age ≥ 95th percentile

Dr. Bahram Pourghassem Gargari
Department of Nutrition and Biochemistry
Faculty of Health and Nutrition
Tabriz University of Medical Science and Health Services
Tabriz, Iran
E-mail: bahrampg@yahoo.com

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Counter-response

To the Editor:

I thank Dr. Gargari for his responses to my comments. His paper is now quite clear to me. To wrap up this exchange of views, I would like to share some thoughts that came to my mind while reading these responses.

1. My question was, Why was an old set of data used when the new data for percentile cutoffs were available? The NHANES I is a set of data collected from 1971 to 1974 in the United States. NCHS/CDC 2000 was also based on US data from 1963 to 1994. However, the weight and BMI of the group above six years of age were excluded from NHANES III to prevent any distortion that could arise due to the increase in the prevalence of obesity during that period. (IOTF also did not use this data set when they used data from the United States.)

   WHO would have recommended NHANES I because at that time it was the best. However, when the CDC 2000 charts became available, they would have not done so because by that time they had their own growth chart project as well as IOTF functioning.

   My personal reservation about the IOTF cutoffs is about whether they are truly world representative. They do not include any South Asian or Middle Eastern countries (the two Asian countries included mainly subjects of Chinese ancestry). It is very well known that South Asians have a low BMI but a high percentage of fat mass, and even WHO thinks that the BMI cutoff for adults in the subcontinent should be as low as 27 kg/m^2. (Some of the work I did on Sri Lankan migrant children in Australia had similar results. I failed to detect a single case of obesity based on IOTF, but the children had a very high percentage of fat mass [1,2]). This could also be the case for children in the Middle East. Therefore, ideally we should cross-validate these cutoffs before we apply them, otherwise they could really be underestimating the problem.
2. I agree with you and I hope the age had a normal distribution. I wish this had been explained in the text. However, my personal belief is that rather than using a shortcut, it would have been better to analyze individual cases in order to determine the prevelance. In the example I have quoted it is clear that results do get distorted if there is an imbalance in the distribution of the ages.
3. This is an observation I have made in my work, and it would have been the case if you had used the CDC 2000 charts.
4. I wish these references had been quoted in the text. However, I believe that you will agree that in the WHO Technical Report 854 [3] has stated that "BMI was recommended as the basis for anthropometric indicators of thinness and overweight during adolescence"[3], and that it has described BMI below 5th percentile as indicating thinness rather than underweight and has not entertained a gradation of underweight in this age category. Further, I think that even the CDC uses BMI below 5th percentile as indicating underweight rather than severe underweight. Therefore, I believe there should be uniformity in defining various types of nutritional status.This will make it possible to compare data from various countries and regions and provide a more meaningful context to future research.

Dr. Pujitha Wickramasinghe

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What can food policy do to redirect the diet transition?

International Food Policy Research Institute (IFPRI) Discussion Paper 165 (December 2003)

Lawrence Haddad

Key words: Food policy, diet transition, health outcomes

In the twenty-first century, developing countries will have to cope with the transition from acute disease to acute plus chronic disease. The two main contributors to this trend are diet and activity levels, both of which are changing at historically rapid rates. This paper focuses on dietary changes. Where good data on food consumption are available, they show that the availability and intake of foods that are risk factors for chronic diseases are increasing rapidly in urban and rural areas and across all income groups. Increases in overweight and obesity rates in the developing world show similar patterns. The coexistence of a double burden of undernutrition and "overnutrition" adds to human suffering and economic costs. It also complicates the design of food policy.

This paper asks: "What can food policy do to redirect the transition in diets toward healthier outcomes?" The paper reviews the drivers of the changes in diet and the potential of both demand- and supply-side food policy options to influence the drivers. The paper ends by highlighting the challenges posed to food policy design by the coexistence of—and linkages and trade-offs between—under- and overnutrition.

Drivers of Dietary and Nutrition Trends

The commonly listed drivers of consumption trends include (1) income growth, (2) changes in relative prices caused by technology, institutional, and policy changes, and (3) the socioeconomic and activity changes associated with urbanization.

As income grows, consumers want to diversify out of cereals and other starchy staples. The consumption of the poorest households tends to be most responsive to increases in income. Preliminary simple regression analysis of producer prices in Nigeria, South Africa, and India did not demonstrate any significant systematic differences in relative price increases by food category. In China, however, oils low in saturated fats (soybean, sunflower, rapeseed, and sesame) posted significantly higher price increases over the 1976–95 period than palm oil (high in saturated fat), which showed one of the lowest price increases over the period. In the United States, the price of nonalcoholic beverages (dominated by carbonated sweetened soft drinks) dropped dramatically over the 1982–97 period compared to an all-food average, as have the prices of dairy products, fats and oils, eggs, meat, poultry, and fish. Projections of the internationally traded prices for nonstaple, nonfruit, and nonvegetable goods indicate a continuation of these trends.

More analyses of past trends in producer and retail food prices need to be undertaken from a health perspective. For example, we do not have consumer food price trends by fat content or, preferably, by type of fat content. Such trends would help identify the main sources of any decline or increase in the price of fat or added sugar. Such information, as we will see, is important for policy formulation. In addition, more studies are needed that seek linkages between price trends and health outcomes. Many studies link undernutrition to price changes but few link rates of chronic disease or obesity to relative price changes while controlling for a range of other factors. Two of the few such studies to do so using U.S. data suggest that 40 percent of the growth in weight of the U.S. population between 1976 and 1994 is due to technology-based reductions in food prices.

Technology innovation and policy may be one important source of change in the relative prices of foods that pose a chronic health risk; institutional policy changes are another. For example, more research is needed from a health perspective on how trade liberalization (e.g., China's membership of the WTO and its impact on edible oil prices faced by Chinese consumers) will affect the price of different foods that represent different health risks.

Urbanization is proceeding rapidly in the developing world and is accompanied by a marked reduction in physical activity for the majority of the labor

force. The higher population density of urban areas lowers the per person cost of mass-media advertising, where the spending power of food manufacturers and processors surely outweighs that of public health authorities. The urban environment is also marked by a greater physical disconnect between places of work and residence and smaller household sizes, especially for women. In this environment, free time is scarcer, at least for those gainfully employed, and where the fixed costs of food preparation are higher in smaller families, more food tends to be purchased outside the home even for poor households. This food tends to be much more highly processed, and higher in salt and fat.

What can food policy do?

What is the rationale for public action to steer the diet transition toward greater healthiness? Perhaps the most obvious rationale is information asymmetry between producers and consumers about what is and is not healthy. The paper reviews options from the supply and demand sides and discusses some of the trade-offs between addressing under- and overnutrition that are accentuated in developing countries.

Possible supply-side interventions considered include (1) more public investment in technology to deliver high-productivity, low-cost vegetables and fruits and low-fat livestock products to poorer consumers, (2) eliminating incentives on growing high-fat foods and relaxing restrictions on growing healthier foods, and (3) evaluating food trade policy from a health perspective.

Demand-side interventions considered include (1) increasing the relative cost of purchasing unhealthy choices (either through changing location of purchases or price), (2) providing clearer information about product contents, and (3) improving awareness about consequences of poor diet.

Policy formulation on dietary change in the developing world must build on the evidence base accumulated in the industrialized world. However, the developing country context is very different. First, policymakers in the developing world are faced with food consumption deficits. Second, certain groups need to consume even foods that are "empty" sources of the dietary component being discouraged, e.g., edible oils, to increase the energy density of infant complementary foods. Third, the capacity to influence preferences via the public sector is likely to be lower than in the industrialized world.

Finally, it is important to note that food represents a class of commodities that is difficult to influence in a predictable manner—for example, efforts to increase the price of high fat products will also increase the price of any micronutrients they contain. Moreover, food is not yet like tobacco, in that there are fewer "triggers" in place for strong public action to occur.

Information and analysis gaps

Research in the area of diet transition in developing countries is in its infancy. Most of the work has been spent documenting the transition and, to a lesser extent, analyzing its causes. Much of this work has made do with crude food consumption data, and very little research has focused on policy analysis.

The paper suggests that (among other things) there is a need to (1) use existing nationally representative household survey data to systematically chart trends in availability of "bad" diet components, (2) better connect the location of food purchase and the health content of that purchase, (3) generate food-price elasticities for large developing countries that are disaggregated enough to be policy relevant (e.g., "edible oil" is not useful, but "high-saturated fat edible oil" is), (4) evaluate nonprice interventions to change diets, both in terms of quality and quantity, (5) spell out the trade-offs in terms of the consumption changes of different dietary components of different population subgroups resulting from the change in the price of a single commodity and the implications for smallholder income generation, and (6) conduct more research on the investments and institutional innovations that smallholder farmers need to link up with growing domestic and international markets for healthy foods.

Conclusion

The diet transition in the developing world seems to be accelerating. It seems to be a transition toward an increased burden of chronic disease. It is increasing human costs in terms of mortality and the disease burdens, and it is increasing economic costs in terms of lower productivity. It is driven by changing preferences fueled by growing incomes, changing relative prices, and urbanization; by changing food choice options fueled by changes in food technology and in food distribution systems; and by a legacy of low birth weights from the previous generation. Is there a case for public investment in efforts to influence the transition toward increasingly healthy outcomes? The existence of information asymmetries and negative externalities suggests that there is.

What can food policy do? We have identified a number of options from the food supply and demand sides. These options have had mixed success in industrialized countries. The policy trade-offs in the developing world are even more complicated. For example, efforts to overcome overnutrition might undermine efforts to overcome undernutrition. The public health

antismoking policy model offers some insights, but it should not be leaned on too heavily—food is not tobacco. There are plenty of areas in which additional technical research is needed to assess competing risks and to help develop policy options. But there is also a great need for research to engage actors in the policy process underlying the diet transition. In a debate where so much is at stake—market shares, profits, livelihoods, and life itself—there is a potentially powerful role for researchers to bring different actors to the table. This may help to improve the decisionmaking processes underlying the attempts of food policy to redirect the diet transition toward healthier outcomes.

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From research to program design: Use of formative research in Haiti to develop a behavior change communication program to prevent malnutrition

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Purnima Menon, Marie T. Ruel, Cornelia Loechl, and Gretel Pelto

Key words: Child-feeding practices, childhood malnutrition, caregiving behaviors, formative research, program design, Haiti

Positive changes in child health and nutrition are manifested in many forms, including improved growth and development and reduced morbidity and mortality. Each child health outcome results from complex interactions between community, familial, and caregiver resources that, in turn, lay the ground for either optimal or poor caregiving behaviors.

Background: Purpose of behavior change communication programs

For children to grow normally, there are many parental caregiving behaviors related to food that are essential to ensuring adequate nutritional intake: obtaining and selecting foods that meet nutritional requirements, preparing them safely and in a form that is appropriate for the child's age, and feeding them in a manner that encourages adequate intake. To engage in these critical caregiving behaviors, parents need access to the foods their children require; fuel, water, and other materials to prepare and preserve these foods; and the time and energy to carry out the activities. They also need knowledge. These are essential underpinnings of nutrition and health-giving behaviors, and the prerequisites for child health and well-being. Because caregiving behaviors are the links between resources, knowledge, and child health, programs that seek to improve child health and nutrition must, by definition, change caregiving behaviors. Programs that aim to improve child outcomes by improving childcare behaviors are collectively referred to as behavior change communication (BCC) programs.

Purpose and methodology of this study

This paper summarizes findings from a formative research study conducted in Haiti to develop a BCC strategy to improve infant- and child-feeding practices and to reduce childhood malnutrition. It also describes the tools developed to facilitate decision-making and effective use of formative research for program planning.

The study used formative research methods that included individual and group interviews, food rating exercises, and participatory recipe trials. The aims of the study were to

1. Study current infant- and young child-feeding practices in the Central Plateau of Haiti;
2. Identify individual, household, and community factors that may facilitate or constrain adoption of recommended behaviors; and
3. Use the information from the formative research to prioritize behaviors to be targeted and design an effective BCC strategy.

Results

The study revealed some nonoptimal infant and young child-feeding practices in this part of rural Haiti, such as low rates of exclusive breastfeeding, early introduction of nutrient-poor gruels, and the scarcity of nutrient-dense foods such as animal products in the diet. A number of constraints were also identified that may limit the ability of families to engage in optimal feeding practices. These include the early resumption of work outside the home by women, which is driven by economic necessity and results in frequent and sometimes long separations of the mother from her young infant. The lack of time to prepare special complementary foods for the child, the perception that 12-month-old infants are ready to consume the family diet, and the low availability of micronutrient-rich foods (animal-source foods in particular) are additional constraints on poor families to achieving optimal child-feeding practices.

The data also highlighted some facilitating factors that could be used to design locally relevant and

powerful communication messages. The few mothers who reported having exclusively breastfed their infants, for example, emphasized that this practice improved their infants' health and reduced healthcare costs. Similarly, the absence of cultural restrictions regarding feeding animal-source foods to infants and young children, and the knowledge among some mothers that these foods are good for children, are positive factors likely to facilitate behavior change related to these practices. The recipe trials also provided valuable insights regarding feasible, affordable, and acceptable recipes for enriched complementary foods that could be promoted through the BCC intervention.

Organization of results into a "decision tool"

To simplify interpretation of the findings, we organized the information gathered into a decision tool. This tool consists of a matrix containing the following elements:

1. A goal to achieve,
2. Practices to promote to achieve this goal,
3. Current practices in the population studied,
4. Facilitating conditions for behavior change, and
5. Issues that may affect the capacity for behavior change (e.g., potential constraints).

A second, complementary matrix summarizes the constraints and facilitating factors identified for the different practices and includes columns to identify programmatic options (either within or outside of the current program context) to alleviate some of these constraints or to optimize use of facilitating factors in promoting behavior change.

Conclusion

The use of formative research for program design proved extremely useful, especially for identifying priority areas of intervention. The decision tool developed in this study helped to structure the large amount of data gathered, and it allowed presentation of the information in a systematic, clear, and easy-to-grasp manner. The tool also proved valuable in discussions related to program planning, as it helped build consensus and set priorities for action in the short and long term.

In Haiti, the tool was used after World Vision's five-year program cycle had been established. This limited the flexibility of the program to design interventions that are outside of their current mandate. In the future, formative research and the type of decision tool developed in this study should be used to plan forthcoming program cycles. This would help ensure that constraints to behavior change are addressed though appropriate programmatic interventions, even if these may be outside of the usual scope of activity of the implementing agency.

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Book reviews

Phytochemicals in health and disease (oxidative stress and disease). Edited by Yongping Bao and Roger Fenwick. Marcel Dekker, New York, 2004. (ISBN 0-8247-4023-8) 384 pages, hardcover. US$195.

Interest in the role of phytochemicals in the diet for disease prevention has risen rapidly in recent years as the scientific evidence has provided increasing confirmation of their importance. This book, by contributors from 16 institutions in 8 countries, describes the functions, metabolism, and biological activities of selected phytochemicals and documents their role in the modulation of enzyme activity and gene expression. It presents the latest molecular evidence for biological effects of selected phytochemicals on cellular processes involved in cancer, cardiovascular disease, and hypertension. The phytochemicals are found in fruits, vegetables, teas, and spices.

Chapter 1 introduces the fundamentals of nutritional genomics (nutrigenomics), chapter 2 the factors affecting bioavailability, and chapter 3 reviews the role of polyphenols. Chapters 4 through 6 present specific compounds that may influence the risk of cancer, including genistein-induced gene expression; ginkgo biloba extracts, and isothiocyanate sulforaphane. Chapter 7 demonstrates how heterocyclic amine-induced DNA adduct formation, a biomarker of DNA damage and risk of cancer, can be affected by phytochemicals. Chapters 8 through 11 are devoted to consideration of the two main classes of phytochemicals—organosulfur compounds and polymethylated flavonoids. Chapter 12 summarizes the role of dietary phytochemicals in the prevention of cardiovascular disease, while chapters 13 through 15 examine the action of resveratrol, lycopene, and oltipraz. The concluding chapter elaborates on these as it addresses research directions, challenges, and opportunities.

The significance of phytochemicals in the diet is of such great interest to health workers that this book provides a very useful source of current knowledge. Although written for the research and scientific community, the editors have presented the information in a manner that should be understandable and conveyed accurately to science writers and the general public, especially in light of the demonstrated health significance of some phytochemicals.

Towards the global elimination of brain damage due to iodine deficiency. Edited by B. Hetzel (senior editor), F. Delange, J. Dunn, J. Ling, V. Mannar, and C. Pandav. Oxford University Press, New Delhi/Oxford, 2004. (ISBN 019-567095-7) 578 pages, softcover. US$20.

Basil Hetzel, the senior editor of this substantial book, has been the global leader in alerting governments, international agencies, and nutrition and health workers to the high prevalence and grave consequences of iodine deficiency. The most serious is the impact of iodine deficiency in pregnancy on the development of the fetal brain. Unfortunately it is too late to correct the deficiency after birth. In much of the world iodine is deficient in the environment due to glacial ice or heavy rainfall, and the distribution of IQ is lower without the availability of salt or some other staple with added iodine.

An introductory chapter gives the history and magnitude of iodine deficiency disorders (IDD). The global program for the elimination of brain damage due to iodine deficiency promoted by the International Council for Control of Iodine Deficiency Disorders (ICCIDD) to engage the international, bilateral, nongovernmental agencies and the salt industry is well described. As pointed out in a section of the book, the program bridges the gap between research and application through the multiple partners. The scientific basis for the elimination of brain damage due to iodine deficiency is thoroughly discussed as are the problems related to production of iodized salt and the role of education and communication.

In general the global program has been a great success as the iodation of salt is in various stages of implementation in most countries at risk of IDD. Individual chapters describe the process in Africa, Asia,

Central Europe, China, the Middle East, North Africa, Southeast Asia, and the Americas. Once implemented, iodization must be sustained permanently. Examples are given of countries that achieved universal salt iodation, thus eliminating IDD, only to have it recur when monitoring and enforcement was discontinued due to political turmoil. An appendix provides valuable documentation of the progress of the campaign to eradicate IDD country by country.

The subtitle of the book, "A global program for human development with a model applicable to a variety of health, social and environmental problems" is well justified. It is not only the most complete account available of a remarkable public health campaign, but is also useful to those promoting other public health initiatives. The book is also available as a CD-ROM from the ICCIDD. For information, send e-mail to cpanday@iqplusin.org. For the ICCIDD newsletter, available free of charge, visit http://www.iccidd.org.

Mendel in the kitchen: A scientist's view of genetically modified foods. Nina Fedoroff and Nancy Marie Brown. Washington, D.C., National Academies Press/ Joseph Henry Press, 2004. (ISBN 0-309-09205-1) 370 pages, hardcover. US$24.95.

There is a great need for this balanced and authoritative treatment of the issues surrounding the application of biotechnology to the improvement of food crops. The preface points out that all of the food crops we depend on today are the result of human manipulation, emphasizing that we cannot turn back the clock because the human population is too large and the available land too small. As the authors put it, "The challenge of the coming decades is to limit the destructive effects of agriculture even as we coax ever more food from the earth." They describe how the task is made less daunting by new knowledge and new methods—if they are wisely used.

The first chapters review the profound genetic changes induced in crops that are now considered natural, including examples of past, fierce resistance to new foods, such as the potato, when it was introduced in Europe, and the flexible barriers between species even with so-called conventional breeding techniques. Transgenic techniques for creating new plant varieties are described with an emphasis on the properties of the product, not the way in which it has been produced. Yet in most countries today plants, modified using molecular tools, are subjected to evaluation by multiple agencies and restrictive legislation never applied in the past to induced mutation with equally profound results on the resulting cultivars.

A large section of the book is devoted to the possible risks and hazards of genetically modified plant varieties. Eating any food is potentially dangerous, and all new foods need to be screened for safety regardless of how they are produced. However, when plants are engineered to produce new proteins that may affect human health the foodstuffs made from them must be carefully evaluated. The possible risk of introducing an allergen through plant breeding is thoroughly discussed. It is also demonstrated that breeding can make plant varieties safer and healthier.

The book investigates in depth some of the claims that have been made for the risks for human consumption and the environment of genetic modification of plant potential hazards, and exposes the poor science, or lack of science, behind them. It also documents the impossibility of feeding the present population of the earth with the plant varieties available in 1961. The challenge for the 21st century is to greatly increase our food supply on roughly the same amount of land in production today. Despite the appeal of "organic farming," the book estimates that the world has less than 20% of the organic nitrogen needed to support global organic farming. The conclusion is we will need all of the help available from new technologies to meet the food requirements of 2 billion more people by mid-century.

The authors investigate many examples and claims, use frequent quotations, and thoroughly document their conclusions in each chapter. An extensive bibliography is provided. This book is written from the objective viewpoint of an outstanding scientist and published through the National Academies Press. *Mendel's Kitchen* makes for informative reading, and for the scientist or the lay person willing to consider objectively the scientific evidence for and against genetically modified foods, it will prove easy to follow and promote an understanding of the complex issues surrounding the remarkable and essential advances of food technology. Negative claims and political issues are not ignored, but rather discussed with the knowledge of the best available evidence. The book should be made available in many languages, and widely circulated. It is strongly recommended for all concerned with the subject it deals with.

Adult obesity: **A paediatric challenge.** Edited by Linda D. Voss and Terence J. Wilkin. Taylor & Francis, New York, 2003. (ISBN 0-4153-0015-0) 112 pages, hardcover. US$99.95.

There is concern in Great Britain that levels of obesity have tripled in the last 20 years to the highest rates in Europe, and are approaching those in the United States, where one person in four is obese. It is clear that obesity and many associated adult diseases begin in childhood, which makes adult obesity a challenge for pediatricians. This small volume presents a series of essays from a 2001 National Symposium on Obesity

in the United Kingdom. It attempts to provide answers to such questions as: What are the early factors responsible for adult obesity? To what extent do fat children become fat adults? and What can be done to halt the trend toward adult obesity?

Individual topics include obesity as a global problem; over-nutrition and under-activity, role of genes, social inequities and obesity, and effect of self-image and self-perception.

The chapters explore the pediatric origins of obesity and the role of primary health care. The final chapter is devoted to the title theme of adult obesity as a pediatric challenge. This small, well-written book will be useful to all health workers concerned with preventing obesity and its outcomes.

Guidelines for the inpatient treatment of severely malnourished children. A. Ashworth, S. Khanum, A. Jackson, C. Schofield. WHO, Geneva, 2003. (ISBN 92-4-154609-3) 48 pages, softcover. US$9.

This book provides simple, practical guidelines for successfully treating severely malnourished children. It also takes into account the limited resources available in many hospitals and health units in developing countries. The book is directed toward health workers, dietitians, nurses, and doctors, as well as their trainers and supervisors.

Substantial reductions in mortality are reported by hospitals using these guidelines, with mortality rates of 30–50% having fallen to 5–15%. The aim is to assist in improving the quality of inpatient care, and prevent unnecessary deaths. The guidelines are authoritative, and the instructions clear and concise.

These guidelines can be used as a practical 10-step treatment tool and as additional support material to the WHO training courses on severe malnutrition management.

Perinatal nutrition: Optimizing infant health and development. Edited by Jatinder Bhatia. Marcel Dekker, New York, 2004. (ISBN 0-8247-5474-3) 440 pages, hardcover. US$179.95.

The high infant mortality rates in developing countries are due about equally to neonatal and postnatal mortality. In turn, neonatal death in the first month of life is a significant and most intractable component of infant mortality. This book presents nutritional strategies for the care of perinatal patients from preconception through infancy. So regardless of the quality and value of the 14 chapters the book title is misleading. The first five chapters deal with maternal nutritional factors, many of which contribute to perinatal mortality. The next six chapters cover aspects of nutrition throughout infancy. Two chapters deal with prenatal and infant nutrition in the pathogenesis of type 1 diabetes and with adolescent preconception. A final chapter discusses the ethical issues of artificial hydration of the neonate, but the application to actual clinical conditions is not specified.

The book contains recommendations for iron and vitamin intake and energy expenditure-based maternal body-mass index (BMI), and reviews current routines in infant nutrition. The information provided is appropriate and timely, however, the contents are not described by the title of the book, therefore the audience for this publication is not clear.

—Nevin S. Scrimshaw

News and notes

PAHO/WHO promotes the new international growth curves in the region of the Americas

Growth references are among the most commonly used and valuable tools for assessing the health and well-being of individuals, groups of children, and the communities in which they live. However, the current international reference, the US National Center for Health Statistics (NCHS)/WHO International Growth Reference poses major limitations, and incongruities are presented by the apparent poor growth of healthy breastfed infants of well-nourished women living in favorable conditions. In the early 1990s, the Working Group on Infant Growth convened by the World Health Organization (WHO) concluded that new references were necessary and that it was time to consider the production of references that would more closely approximate standards, i.e., to describe how children should grow in all settings rather than a description of how children grow in a specific setting and time. In 1997 WHO, in collaboration with a number of institutions worldwide, began to conduct a community-based, multi-country study to develop new international growth references for infants and young children—the Multicentre Growth Reference Study (MGRS). Data collection was completed in late 2003, and by the end of 2005, operational materials (i.e., growth charts, software, training materials, etc.) are expected to be ready for dissemination and implementation at the country level. The MGRS rationale, planning, and implementation document was published in the *Food and Nutrition Bulletin* in March 2004 (Vol. 25, No. 1 [Supplement 1]).

In preparation for the implementation phase and as part of a broader global work plan, the Pan American Health Organization (PAHO) conducted a regional consultation with the purpose of promoting the new international growth standards by sharing details of the MGRS, reviewing the current use of growth charts and practices in child growth monitoring, and discussing the implications of implementing the new standards, in order to elaborate a dissemination strategy for adopting them in the PAHO Region (i.e., Latin America). The regional consultation, the first in the Region and part of a worldwide process, was organized by the PAHO Nutrition Unit with key members of the MGRS Executive Committee. It was hosted by the Research Center in Nutrition and Health of the National Institute of Public Health of Mexico (Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública, CINyS/INSP). The two-day meeting took place on December 9-10, 2004, in Cuernavaca, Mexico.

Representatives of the Maternal and Child Health, Nutrition and/or Immunization Programs of the Ministries of Health and representatives of national pediatric societies from eight Latin American countries gathered to exchange experiences and lessons learned and to discuss actions to improve child growth monitoring. Participants from the United Nations University (UNU), the International Union of Nutritional Sciences (IUNS), the University of Chile, the Epidemiological Research Center of Brazil, and the Latin American Pediatric Association (ALAPE) also participated to provide their technical expertise and perspectives in the discussion of a regional adoption framework and dissemination strategy. As child growth monitoring involves a wide array of governmental departments, health professionals, academic institutions, and other national and international partners, participants representing some of these various entities were invited to propose how to advocate and plan for the implementation of the new growth standards in the different arenas.

For more information contact: PAHO/WHO Nutrition Unit, 525 23rd Street, NW, Washington, D.C. 20037, USA; tel: 202-974-3853; fax: 202-974-3675; e-mail: kimsunny@paho.org; web address: www.paho.org

PAHO, ILSI, and CDC's "Healthy Lifestyles, Healthy People" Initiative: A three-country pilot project in Latin America

Healthy Lifestyles, Healthy People (HLHP) is an initiative

of the Pan American Health Organization (PAHO), the International Life Sciences Institute (ILSI), and the US Centers for Disease Control and Prevention (CDC). The project's main objective is to make a contribution to obesity and non-communicable disease prevention in Latin America through the evaluation of existing or new population-based dietary and/or physical activity interventions.

The HLHP initiative shares similar goals with the WHO Global Strategy on Diet, Physical Activity and Health, and therefore constitutes an important Regional effort to implement the strategy by providing scientific programmatic evidence, guidelines for policy development, and stakeholder involvement. Oversight for HLHP will be provided by an Executive and a Coordination Committee integrated by PAHO, ILSI, and CDC representatives. In addition, a Scientific Advisory Committee (SAC), with five highly qualified professionals, will assist in reviewing proposals, selecting the best ones for funding, and assessing project results.

At present, the HLHP initiative is concentrating its efforts in three countries—Brazil, Chile, and Mexico. In order to capitalize on the knowledge, strengths, resources, and commitment of the multiple sectors within each target country, ILSI and PAHO are promoting the organization of a local consortium in each country, integrated by representatives from public (e.g., Ministry of Health and other public institutions) and private sectors (e.g., local private companies, scientific and academic institutions). The main activities of the local consortium include identifying promising programs or interventions, promoting their evaluation among local research groups, submitting promising proposals for funding to the SAC, and collaborating in the dissemination and use of the studies' results. In each country, the three best proposals will be awarded a grant of up to US $100,000 each. Local research groups in each country will be invited to develop proposals according to predetermined criteria.

Timeline for proposal selection:

» March 10, 2005: Deadline for submission of pre-proposals
» April 12, 2005: Announcement of selected pre-proposals. The Scientific Advisory Committee (SAC) will select 18 pre-proposals (6 per country)
» April 27–29, 2005: Workshop—one representative from each of the selected pre-proposals will attend a workshop to improve their proposals
» June 30, 2005: Deadline for the 18 pre-selected research groups to submit a full proposal
» July 29, 2005: The SAC will announce the nine awarded project proposals

For more information contact: PAHO/WHO Nutrition Unit, 525 23rd Street, NW, Washington, D.C. 20037, USA; tel: 202-974-3539; fax: 202-974-3675; e-mail: jacobyen@paho.org; web address: www.paho.org

Joint FAO/WHO nutrient risk assessment consultation

An interdisciplinary technical workshop to develop a model for risk assessment for nutrients and related substances will be convened by the Food and Agriculture Organization (FAO) and WHO. Such work will provide scientific advice on the principles and methodologies to be used in conducting risk assessment for nutrients and related substances. It is anticipated that the workshop will be scheduled for May 2005.

For further information, please visit: http://www.who.int/ipcs/highlights/nutrientraproject/en/

FAO/WHO workshop on functional food

The Food and Agriculture Organization of the United Nations (FAO) and WHO jointly organized a workshop on "Functional Foods: Safety and Regulatory Aspects," on September 6, 2004, at the Lotte Hotel Jeju in Jeju-do, Republic of Korea, immediately prior to the 14th Session of the Codex Coordinating Committee for Asia.

For further information, please visit: ftp://ftp.fao.org/es/esn/food/meetings/2004/korea_report.pdf

Global Strategy on Diet, Physical Activity and Health (World Health Organization, 2004)

Responding to concerns over the threat of an epidemic of diet-related noncommunicable diseases (NCDs) such as heart disease, certain types of cancer, diabetes, and obesity, WHO prepared a Global Strategy on Diet, Physical Activity and Health, which was endorsed by the World Health Assembly in May 2004. The full text of the strategy is available in several languages at: http://www.who.int/dietphysicalactivity/strategy/eb11344/en/

Marketing food to children : The global regulatory environment (World Health Organization, 2004)

As part of the strategy development process, WHO has been examining a range of interventions that have the potential to play a role in tackling the globally rising rates of noncommunicable diseases. In this respect, the regulation of the marketing of food, especially to children, has emerged as one area necessitating

further attention. This document reviews the regulatory environment that surrounds the marketing of food (including nonalcoholic beverages) to children. It is available at: http://whqlibdoc.who.int/publications/2004/9241591579.pdf

Nutrition labels and health claims: The global regulatory environment (World Health Organization, 2004)

This review of the global regulatory environment concerning nutrition labeling and health claims aims to provide an overview of existing international, regional, and national regulations and a description of past and future regulatory developments. It compiles, categorizes, and tabulates international, regional, and national regulations, and compares differing regulatory systems in 74 countries and areas. It also reviews regulations on the quantitative declaration of ingredients (information that indicates to consumers the proportion of healthful to less healthful components of the food product). The report is available at: http://whqlibdoc.who.int/publications/2004/9241591714.pdf

Fruit and vegetables for health. Report of a FAO/WHO workshop (World Health Organization/Food and Agriculture Organization of the UN, 2005)

In 2003 FAO and WHO joined forces to promote the production and consumption of fruit and vegetables for health. This workshop, bringing together health and horticulture scientists, developed a framework for the promotion of fruit and vegetables at the national level and reviewed current science on the health effects of fruit and vegetables, the effectiveness of fruit and vegetable promotion programs, and production trends. The report and the background papers are available at: http://www.who.int/dietphysicalactivity/fruit/en/

Protecting and promoting good nutrition in crisis and recovery. A resource guide (in press)

This book complements the Technical Handbook Series on FAO's Emergency Activities. It offers guidance in adopting a longer-term perspective in addressing problems of household food insecurity and malnutrition during periods of crisis and recovery. It provides a framework for an implementation strategy that focuses not only on saving lives in the short term, but also on strengthening livelihoods to ensure that households are less vulnerable to food and nutrition insecurity in the future.

The book presents different types of interventions in areas that range from promoting improved food production and diversification to improving information systems. It provides examples of how the these interventions can be translated into actions to protect and promote good nutrition. The book will be relevant and useful to planners and technicians in the fields of nutrition, food security, agriculture, and community and social development who are able to "cross over" from relief to development modalities of working and who recognize the need to adopt a multisectoral approach to achieving the common goal of improved nutritional well-being.

Family nutrition guide (FAO, Rome 2004)

The *Family Nutrition Guide* is basic nutrition education material, written primarily for health workers, nutritionists, agricultural extension workers, or other development workers in developing countries. It provides an up-to-date summary of relevant nutrition information and gives many suggestions on how to share this information when working with groups of people. The guide will also be useful for training and is a resource for designing more effective nutrition education curricula and material.

While the illustrations and food examples in this guide mainly reflect the situation in countries of Eastern and Southern Africa, the basic information is relevant for all regions. Similar nutrition education material for developing countries worldwide can be prepared using this book as a guide. Suggestions for adapting the guide's technical information to other areas, as well as for preparing a specific country version, are given.

The guide is divided into 11 topics that cover basic nutrition, including micronutrients, family food security, meal planning, food hygiene, and the special feeding needs of children, women, and men, and of elderly, sick, and malnourished people.

Guide for planning nutrition education curricula (coming in 2005)

The overall goals of school nutrition education programs are to improve the health and nutrition status of schoolchildren and to establish lifelong healthy eating habits and life styles among the school population. Using this planning guide can result in a variety of action programs planned and carried out at either the local or national level, or both. Applying the planning process promoted in the document, these action programs will be specifically tailored to suit local, regional, or national circumstances and resources.

The planning guide is aimed at establishing effective

nutrition education programs in schools involving the family, the community, and all relevant sectors and stakeholders. It comes in two volumes, a technical reader and a collection of activity sheets. The main use of the planning guide will be in curriculum development covering activities both in the school environment and in the classroom; it may also be drawn upon for policy formulation and for advocating nutrition education in schools. The guide can be an instrument for teacher training and development and institutionalized in teacher education programs. It is considered essential preparation for the development of teaching materials and lesson plans for nutrition education.

In Memoriam

George Davis, pioneer in animal nutrition research, dies at 94

George Kelso Davis, the University of Florida researcher whose pioneering work in micronutrients gave a lift to Florida's once-ailing cattle industry, died October 27, 2004, in Gainesville. He was 94.

"He was an outstanding scientist and a man of great accomplishment," said Bob Cousins, an eminent scholar in nutritional biochemistry at the University of Florida Institute of Food and Agricultural Sciences.

Educated as a biochemist, Davis filled a wide variety of roles at the University of Florida, from animal science researcher to head of the university's nuclear sciences program. He was the first University of Florida faculty member to be elected to the National Academy of Sciences.

Born in Pennsylvania, Davis received his bachelor of science degree from Pennsylvania State University and his Ph.D. from Cornell University.

He came to the University of Florida in 1942, at a time when cattlemen often had trouble raising cows in the Sunshine State. Cattle seemed to be unable to put on weight while grazing on pastures in some areas of the state, even when the grass seemed lush and healthy.

"When I came to Florida, I was told, in all seriousness, that purebred cattle could not survive in Florida," Davis said in a 1992 speech commemorating his 50th anniversary at the university.

Davis believed the problem could be traced to deficiencies in trace metals, such as copper or zinc, in the diets of livestock. By feeding radioactive isotopes of zinc, copper, and other trace metals to animals, he was able to track their use in animal metabolism and prove that the metals were vital to the animals' health.

His work led to the use of trace metals as nutritional supplements for cattle, not just in Florida, but also in parts of Asia, Africa, and South America where soils are deficient in those metals.

"We wanted to know why you could put cattle on a seemingly lush field and see them starve," said Bill Davis, the researcher's son. "When he was done, you could put 10 times the number of cows on the same field and see them put on 250 pounds each."

His work with radioisotopes and his ability to attract large research grants led University of Florida administrators to appoint him director of the university's fledgling nuclear sciences department in 1960. The University of Florida Nuclear Sciences Building was constructed during his tenure in the position. In 1965, he was appointed director of the university's biological sciences program.

From 1970 to 1975, Davis served as the University of Florida's Director of Sponsored Research, overseeing research funding for the entire university. Sponsored research funding grew from $18 million to $35 million per year during that time.

In 1976, Davis was elected to the National Academy of Sciences. He was the first University of Florida professor to be so honored.

After retiring from his administrative positions in the late 1970s, Davis continued his research in animal nutrition, investigating the role of plant compounds that have been linked to the development of cardiovascular disease in livestock, pets, and laboratory animals.

"Much of his work addressed fundamental questions, but he always tried to balance it with applied research," said Cousins. "He wanted to do work that offered a tangible benefit to society."

By Timothy Lockette, Institute of Food and Agricultural Sciences, University of Florida. Reprinted with permission.

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1. Alvarez MI, Mikasic D, Ottenberger A, Salazar ME. Caracteristicas de familias urbanas con lactante desnutrido: un análisis critico. Arch Latinoam Nutr 1979;29:220–30.

—corporate author:

2. Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36:119–25.

Book or other monograph reference

—personal author(s):

3. Brozek J. Malnutrition and human behavior: experimental, clinical and community studies. New York: Van Nostrand Reinhold, 1985.

—corporate author:

4. American Medical Association, Department of Drugs. AMA drug evaluations, 3rd ed. Littleton, Mass, USA: Publishing Sciences Group, 1977.

—editor, compiler, chairman as author:

5. Medioni J, Boesinger E, eds. Mécanismes éthologiques de l'évolution. Paris: Masson, 1977.

—chapter in book:

6. Barnett HG. Compatibility and compartmentalization in cultural change. In: Desai AR, ed. Essays on modernization of underdeveloped societies. Bombay: Thacker, 1971: 20–35.

World Wide Web reference

7. WHO HIV infections page. WHO web site. Available at: http://www.who.int/topics/hiv_infections/en/. Accessed 12 October 2004.
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