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Carotenoid content and flesh color of selected banana cultivars growing in Australia

Lois Englberger, Ron B. H. Wills, Barbara Blades, Lisa Dufficy, Jeff W. Daniells, and Terry Coyne

Abstract

Background. *The problems of vitamin A deficiency and chronic diseases have emerged in recent years in some countries in the Micronesian region. These problems are associated with the dietary shift towards imported processed foods and lifestyle changes. Research in the Federated States of Micronesia indicates that yellow- and orange-fleshed banana cultivars contain significant levels of provitamin A carotenoids.*

Objective. *To identify further banana cultivars that may be promoted to alleviate vitamin A deficiency among children and women and chronic disease problems among adults.*

Methods. *Ripe fruit of banana cultivars growing in Australia (sourced mostly from a field research collection) were assessed for carotenoid content and flesh color. Ten cultivars with yellow or yellow/orange flesh color (including common cultivars of Southeast Asia and the Pacific Islands) were selected and compared with two cream-fleshed cultivars, including* Williams, *of the* Cavendish *group, the most commonly marketed banana worldwide. Carotenoid content was analyzed by high-performance liquid chromatography (HPLC). Flesh color was analyzed by HunterLab colorimetry.*

Results. *The yellow/orange-fleshed* Asupina *(a Fe'i banana) contained the highest level (1,412 μg/100 g) of trans β-carotene, the most important provitamin A carotenoid, a level more than 20 times higher than that of* Williams. *All 10 yellow or yellow/orange-fleshed cultivars* (Asupina, Kirkirnan, Pisang Raja, Horn Plantain, Pacific Plantain, Kluai Khai Bonng, Wain, Red Dacca, Lakatan, and Sucrier) *had significant carotenoid levels, potentially meeting half or all of the estimated vitamin A requirements for a nonpregnant, nonlactating adult woman within normal consumption patterns. All were acceptable for taste and other attributes. The cream-fleshed cultivars had minimal carotenoid levels. There was a positive significant correlation between carotenoid content and deeper yellow/orange coloration indicators.*

Conclusions. *These yellow- or yellow/orange-fleshed carotenoid-rich banana cultivars should be considered for promotion in order to alleviate vitamin A deficiency and chronic disease in susceptible target communities and to provide variety and enjoyment as exotic fruits in both developing and industrialized countries.*

Key words: Australia, banana, carotenoid, chronic disease, Pacific Islands, SoutheastAsia, vitamin A

Introduction

Banana (*Musa* spp.), a term including plantain, grows widely throughout the humid tropics and is a common staple food for many people in developing countries, as well as a popular fruit worldwide. Various cultivars of banana are consumed at the green or half-ripe stage as a cooked starchy vegetable or ripe as a fruit. The Food and Agriculture Organization considers banana the fourth most important food in the world, after rice, wheat, and maize [1]. There are many varieties of banana, mostly based on *M. acuminata* Colla (designated as A) and *M. balbisiana* Colla (designated as B), with a wide diversity of diploidic, triploidic, and tetraploidic hybrid varieties having widely differing properties and composition [2]. There is also a very different but relatively minor and less well-understood

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group called Fe'i bananas, which are mostly confined to the Pacific. The greatest diversity of bananas is in Southeast Asia, including Papua New Guinea, where bananas are believed to have originated [3, 4].

World production of bananas is about 100 million metric tons, but much of this is produced and consumed without entering the market system. Although international trade at 15 million metric tons accounts for only 15% of total production, the volume of bananas is second only to citrus in world fruit trade [1]. However, dessert bananas of the *Cavendish* subgroup (*Musa* sp., AAA group) comprise more than 95% of this trade, and consumers in many industrialized countries have limited exposure to any other type of banana [5].

Vitamin A deficiency is a serious health problem among children and women in many developing countries [6], including Southeast Asia and some Pacific Islands, in particular Micronesia [7–12]. Low stores of vitamin A lead to increased mortality and morbidity and problems with vision and eye health, anemia, and growth, whereas improving vitamin A status through a series of trials in several countries has been shown to decrease overall child mortality by 23% [13]. Supplementation with vitamin A has become a widely practiced public health measure in many countries. However, food-based approaches are still considered the most sustainable strategies for the prevention of vitamin A deficiency. They also have other advantages, including the provision of several nutrients simultaneously [14], empowerment of individuals and households leading to family food production and to wise food selection and preparation methods, and enhancement of cultural pride and identity [15].

Vitamin A itself, retinol, is found only in animal sources, such as milk, eggs, and liver. However, in most developing countries, the main dietary source of vitamin A is provitamin A carotenoids, which are found in plant foods and are commonly characterized by yellow/orange coloration [13]. Of the approximately 50 carotenoids having provitamin A activity, β-carotene is the most important and is the most abundant in foods, followed by α-carotene and β-cryptoxanthin (which have half the vitamin A activity of β-carotene). These provitamin A carotenoids are converted in the mucosal cells to vitamin A. Carotenoid-rich foods, including those rich in lutein, zeaxanthin, and lycopene, may help protect against certain chronic diseases, including diabetes, heart disease, and cancer [16–20]. Thus, it is critical to identify foods rich in provitamin A and other carotenoids for health benefits in both developing and developed countries.

Bananas of the *Cavendish* group (including the *Williams* cultivar) contain low levels of provitamin A carotenoids, ranging from 21 to 70 μg of β-carotene per 100 g of edible portion [21–23]. Recent studies, however, have identified 18 banana cultivars grown in Micronesia that have high levels of provitamin A carotenoids [24–26], which would potentially meet half or all of the estimated vitamin A requirements for a nonpregnant, nonlactating adult woman within normal consumption patterns. Because carotenoid levels increase with maturity of the plant [27], the focus has been on ripe samples. Among carotenoid-rich cultivars, β-carotene levels ranged from 330 to 8,508 μg/100 g, and α-carotene and β-cryptoxanthin levels ranged from 280 to 1,800 μg/100 g and from less than 10 to 30 μg/100 g, respectively. The carotenoid content was highest in Fe'i bananas**,** which are characterized by an erect bunch, purple sap, and yellow/orange- or deep orange-colored edible flesh. The coloration of the ripe edible flesh (in these studies ranging from white to cream to yellow to yellow/orange to orange) was a good indicator of carotenoid content, with higher levels in deeper yellow and orange-fleshed cultivars [24–26].

There are many banana cultivars in the Musa Germplasm Information System (MGIS) database of the International Network for the Improvement of Banana and Plantain (INIBAP) that have yellow- or orange-colored edible flesh [28]. However, few have been analyzed for their carotenoid content, as pointed out in a global review discussing the potential of carotenoid-rich bananas [29]. Only a few references name banana or plantain cultivars as good sources of vitamin A [30–33], and one major vitamin A resource book states that bananas are a poor source of vitamin A [34], which is correct in reference to the provitamin A carotenoid levels of *Cavendish* bananas but is not correct for many other banana varieties.

Thus, it is important to initiate activities to identify banana and plantain cultivars with significant levels of provitamin A and other carotenoids and encourage the growth and consumption of such acceptable cultivars in regions of vitamin A deficiency. There could also be a potential market for such cultivars in developed economies, where there is considerable interest in the availability of more nutritious foods and where such cultivars could be advantageously marketed against the *Cavendish* banana, which has a relatively low level of carotenoids.

The aim of this study was therefore twofold: to screen selected banana cultivars available at an Australian research field collection (selecting on the basis of a yellow or orange flesh coloration) and compare carotenoid levels (*trans* β-carotene, *cis* β-carotene, α-carotene, and lutein) with those of common commercially available bananas; and to determine the extent to which flesh color may be used as an indicator of provitamin A carotenoid content.

Materials and methods

An ethnographic approach [15, 35] was taken in various parts of the study, including observation of fruit

flesh color and structured sample collection. Literature review, photography, key informants, and informal focus group discussions (taste panel) provided further information on cultivars analyzed, as approved by the University of Queensland Medical Research Ethics Committee. Oral informed consent was obtained from taste panel participants prior to participating in the panel. The genome and subgroup classification [2] was used to provide international identifications of the cultivars.

Materials

The Queensland Department of Primary Industry and Fisheries (DPI&F) has a substantial holding of more than 400 banana and plantain cultivars from many countries, of which a subset is grown in the North Queensland DPI&F field collection at the South Johnstone Research Station. The fruits of eight cultivars were selected from this field collection, and the fruits of two other cultivars were obtained from nearby growers (*Red Dacca* from Liverpool Creek and *Wain* from East Palmerston). Cultivars were selected that had flesh more yellow or orange in color than that of cream-fleshed *Cavendish* in order to identify those with the greatest potential for carotenoid content. For purposes of comparison, samples of two cultivars with light-colored flesh, *Williams* (of the *Cavendish* group) and *Lady Finger* (a secondary but relatively popular AAB-type dessert banana marketed in Australia), were also obtained from the field collection at South Johnstone Research Station.

Samples of fruit were collected from May to June 2002, taking good-quality, fully ripe fingers.* All samples were prepared raw in order to eliminate differences in carotenoid levels due to cooking treatment.

Samples were prepared from single bunches of fruit for each cultivar except for *Asupina, Kirkirnan, Horn Plantain, Kluai Khai Bonng,* and *Pacific Plantain*, for which separate samples were prepared from fruit of bunches from two plants.

Preparation of samples

In order to provide representative samples, all were prepared as intact composite samples of six whole peeled fingers each, except for one cultivar, *Sucrier* (which had a small finger), for which 12 fingers were included in the sample. In order to provide a description of the fruit for those cultivars analyzed, measurements were taken of the length, girth (at the widest point), and weight (edible portion plus peel) of 12 fingers of each cultivar, and the means were calculated. The flesh color for each sample was described visually by comparing it with a standard set of four colors (cream, pastel yellow, bright yellow, and yellow/orange) from a paint company catalogue. Samples were labeled, placed in zip-closure plastic bags (with air removed manually), and stored in a freezer until the collection of fruit for all samples was completed, a period of around 8 weeks, with most samples being stored for about 4 weeks. The samples were sent to the laboratory by continuous cold-chain transport (using gel-ice and dry ice) via air freight. On arrival at the University of Newcastle laboratory, Ourimbah, New South Wales, the samples were stored at –18°C until analysis, a period ranging up to 9 months. It is unlikely that there was a significant loss of carotenoid content, water loss, or texture changes due to the storage that could have affected the weight and extraction of the samples.

Chemical analysis of samples

All of the raw banana flesh in a sample bag was homogenized by blending in an Omni-Mix for 10 minutes. An aliquot of homogenate (about 5 g) was accurately weighed and dried in a vacuum oven at 70°C to constant weight, and the moisture content was calculated from the loss of weight. Another aliquot of fresh homogenate was smeared on a white tile, and the HunterLab color coordinates of **L** (white-black), **a** (green-red), and **b** (blue-yellow) were measured with a colorimeter (Minolta Chroma Meter CR300). The hue angle (H°) was calculated as $\tan^{-1}$ (b/a) and the Chroma (C) as $\sqrt{(a^2 + b^2)}$.

Analysis of carotenoids was conducted on two aliquots of homogenate. The carotenoids were extracted by the method of Taungbodhitham et al. [36]. This involved adding the homogenate (2 g) to a 4:3 solution of ethanol and hexane (35 mL) containing sodium carbonate (0.05 g), diatomaceous earth (Celite) as a filter aid, an internal standard of β-apo-8'-carotenal (0.2 mg/mL hexane), and an antioxidant (butylated hydroxytoluene [BHT], 0.1% in hexane), then blending the mixture for 5 minutes at 5,000 rpm. The stainless steel vessel was immersed in ice during homogenization to minimize heating of the extract. The extract was filtered through Whatman No. 1 filter paper on a Buchner funnel under reduced pressure. The residue was re-extracted with another 35 mL of ethanol and hexane (4:3) and then washed twice with ethanol (12.5 mL) and once with hexane (12.5 mL). All operations were conducted under subdued light to minimize oxidation of the carotenoids, and all glassware containing extracts was wrapped in aluminum foil to minimize exposure to light. The combined extracts were washed with water and then dried by rotary evaporation in a Rotovap R114. A duplicate sample (20 g) of each homogenate was taken for dry weight determination by vacuum drying in a Thermoline at 70°C for 24 hours.

* A banana finger is an individual fruit, a hand is a cluster of fingers, and a bunch is the entire set of banana clusters harvested from one plant.

High-performance liquid chromatography (HPLC) analysis of the carotenoids was conducted by Hart and Scott's method [37]. The dried extract was resuspended in hexane (5 mL), and an aliquot of solution was injected into a reversed phase column (Vydac 201TP54) that was fitted in a Shimadzu Model 10 HPLC system. The mobile phase consisted of acetonitrile, methanol, dichloromethane (MeCN:MeOH:DSM) 75:20:5 v/v/v, containing 0.1% BHT and 0.05% triethylamine (TEA). The methanol contained 0.05 M ammonium acetate. The flow rate was 1.5 mL/min, and the column eluant was scanned at 450 nm in the UV detector. The identification of carotenoids was based solely on the retention time of a peak compared with the standard. We had standards for all the peaks: *trans* β-carotene, *cis* β-carotene, α-carotene, and lutein. The retention times of peaks on the chromatograms were compared with carotenoid standards and peak areas quantified against standard curves prepared for α-carotene, *trans* and *cis* β-carotene and lutein standards (Roche, Sydney). The amount of carotenoid was calculated as micrograms per 100 g wet weight of banana. The values were adjusted by a correction factor based on the recovery of the internal standard in relation to a standard curve of the standard.

Comparison of carotenoid content of samples analyzed

To compare provitamin A carotenoid levels of the HPLC analysis results, β-carotene equivalent values were calculated by adding the *trans* and *cis* β-carotene contents and half of the α-carotene content. A mean was calculated of the β-carotene equivalents for which composite samples were taken from more than one bunch. From the mean β-carotene equivalents, the retinol equivalent (RE) was calculated for each cultivar using the conversion factor of 6:1 from β-carotene equivalents to RE. The weight of bananas needed to meet half of the estimated daily recommended safe intake (RSI) [38] for nonpregnant, nonlactating women (500 RE/day) and children aged 1 to 10 years (400 RE/day) was calculated from the β-carotene equivalents, since these population groups are particularly vulnerable to vitamin A deficiency [13]. The retinol activity equivalents (RAEs) were calculated by using the newly advised conversion factor of 12:1 for conversion from β-carotene equivalents to RAE [39].

Acceptability and other attributes of *Asupina* fruit

Asupina fingers were transported from the place of harvest in South Johnstone, Australia, to Brisbane, Australia, where a taste panel was organized, composed of 10 adult participants (7 Australians and 3 non-Australians) and including both men and women. A structured questionnaire was provided to the participants to obtain their written comments on the appearance, texture, taste, and marketing appeal of *Asupina* fruit. Some informants were also contacted by e-mail to obtain information related to acceptability and other attributes of these cultivars analyzed.

Results and discussion

Cultivar attributes

Table 1 presents the local names and classifications of the cultivars analyzed and other data describing the

FIG. 1. A bunch of the *Asupina* cultivar, a Fe'i banana, nearly ready for harvest

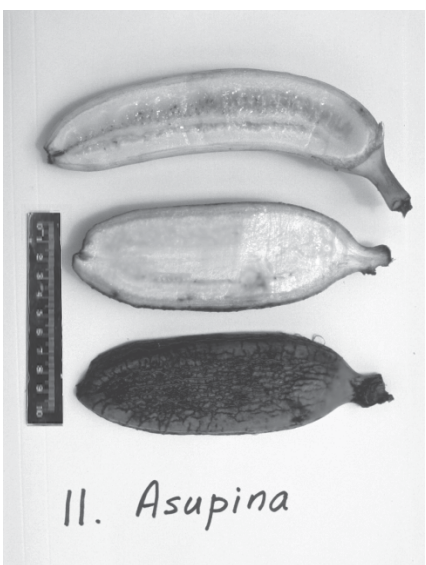

FIG. 2. Longitudinal cross-section of ripe fruit of the *Asupina* cultivar, a Fe'i banana, compared with the *Williams* cultivar, a *Cavendish* banana, showing the darker flesh of Asupina

cultivars. The cultivar set represented two sections (*Australimusa* and *Eumusa*) of the genus *Musa,* including two distinct Fe'i bananas and three genome types (AAA, AAB, AA). Eight of the described subgroups within the latter genome types were represented [2]. The skin color of the fingers ranged from the familiar yellow of *Williams* (common *Cavendish*), to pink-green (*Kirkirnan*), yellow-orange (*Lakatan*), orange (*Asupina*), and orange-red (*Red Dacca*).

There were large differences in finger sizes. The mean finger length ranged from 10 cm for *Sucrier* to 35 cm for *Horn Plantain*. Mean finger girth varied from 9 cm for *Sucrier* to 17 cm for *Pacific Plantain*, which was followed closely by *Asupina* and *Horn Plantain.* The smallest mean finger weight was 35 g for *Sucrier*, with *Pacific Plantain* and *Horn Plantain* having the largest fingers (mean weights, 344 and 319 g respectively). Three cultivars had mean finger weights between 50 and 100 g, and six had mean finger weights from 100 to < 200 g.

Carotenoid content

Table 2 presents carotenoid levels, water content (for comparison by dry weight), and flesh color. The major provitamin A carotenoids detected in all banana cultivars were *trans* β-carotene and α-carotene; *cis* β-carotene was detected but at a much lower concentration.

All of the yellow-fleshed cultivars tested had higher levels of provitamin A carotenoids than the two cream-fleshed commercially available cultivars. The cultivar with the deepest coloration (yellow/orange as assessed visually) was *Asupina*, a Fe'i banana, which had the highest level of *trans* β-carotene (more than 20 times the level of cream-fleshed *Cavendish*) and the highest level of mean β-carotene equivalents of the tested cultivars.

The level of total carotenes in the yellow-fleshed test cultivars ranged from > 400 µg/100 g (lower level) to > 1,000 µg/100 g in 4 of these 10 cultivars. For the five cultivars for which fruit from two bunches was sampled, there was reasonable agreement between bunches of the same cultivar, except for *Kirkirnan*, for which 720 µg of total carotenes per 100 g was found in sample 2 and 2,176 µg/100 g in sample 1. These differences might be explained by maturity, exposure to sunlight, storage, or different transport histories.

For most samples, the total β-carotene level was greater than that of α-carotene, except for *Red Dacca* and *Lady Finger*. Lutein was detected in all samples but was present at much lower levels than β- and α-carotene; most cultivars contained from 10 to < 100 µg/100 g, with Wain containing 146 µg/100 g.

All samples were analyzed as raw fruit, although it is recognized that some cultivars, such as *Horn Plantain* and *Pacific Plantain*, are often consumed cooked, and at different stages of ripeness. Both factors (cooking and maturity) are likely to affect carotenoid levels [27].

TABLE 1. Classification and selected descriptions of the banana cultivars and samples analyzed for carotenoid content

Local name of cultivar[a]	Classification (group/subgroup)[b]	Skin color of ripe fruit[c]	Finger length[d] (cm)	Finger girth[d] (cm)	Finger weight[e] (g)	β-Carotene equivalents[f]	Reference[g]
Asupina	Fe'i	Orange	16	16	140	NA	NA
Horn Plantain	AAB/*Plantain*	Yellow	35	15	319	370; 1,370	40, 41
Kirkirnan	AA/*unknown*	Pink-green	15	11	78	NA	NA
Kluai Khai Bonng	AAA/*unknown*	Yellow	17	12	98	NA	NA
Lady Finger	AAB/*Pome*	Yellow	16	12	86	40	21
Lakatan	AAA/*Lakatan*	Yellow-orange	19	11	109	230, 360	40, 41
Pacific Plantain	AAB/*Maia Maoli-Popoulu*	Yellow	30	17	344	NA	NA
Pisang Raja	AAB/*Pisang Raja*	Yellow	21	13	159	290, 420, 325	40
Red Dacca	AAA/*Red*	Orange-red	18	13	114	417	26
Sucrier	AA/*Sucrier*	Yellow	10	9	35	345, 420	40, 42
Wain	Fe'i	Yellow	14	14	104	NA	NA
Williams	AAA/*Cavendish*	Yellow	26	13	197	21, 105	21, 23

NA, not available in known references

a. Name of cultivar as recorded at the Queensland Department of Primary Industry and Fisheries (DPI&F) field collection, South Johnstone Research Station, Australia.

b. Stover and Simmonds [2] 1987 classification.

c. Color as described visually.

d. Mean calculated from measurements of good-quality unpeeled fingers (n = 12 for all cultivars).

e. Mean calculated from measurements of good-quality unpeeled fingers (n = 12 for all cultivars), including flesh and peel.

f. Carotenoid content determined in prior studies.

g. References for data on carotenoid contents determined in prior studies.

TABLE 2. Carotenoid content of selected ripe raw banana cultivars (μg/100 g edible portion, means of duplicate analyses)[a]

Local name of cultivar[b,c]	Water (%)	Flesh color	*trans* β-carotene[d]	*cis* β-carotene	α-carotene	β-carotene equivalents[e]	Lutein
Asupina #1	80	Yellow/orange: 3–4	1,412	33	296	1,593	74
Asupina #2	78	Yellow/orange: 3–4	1,403	19	185	1,515	51
Kirkirnan #2	78	Yellow: 2	1,092	29	1,055	1,649	17
Kirkirnan #1	76	Yellow: 2	315	21	384	528	7
Pisang Raja	63	Yellow: 2	650	72	508	976	74
Horn Plantain #1	66	Yellow: 2–3	571	85	650	981	28
Horn Plantain #2	64	Yellow: 2–3	567	54	580	911	73
Kluai Khai Bonng #2	77	Yellow: 2–3	535	32	298	716	11
Kluai Khai Bonng #1	76	Yellow: 2–3	288	19	175	395	10
Wain	68	Yellow: 3	486	15	61	532	146
Pacific Plantain #2	73	Yellow: 2	483	25	360	688	22
Pacific Plantain #1	72	Yellow: 2	287	30	346	490	39
Lakatan	66	Yellow: 2	272	17	129	354	25
Red Dacca	77	Yellow: 2	208	6	305	367	80
Sucrier	68	Yellow: 2–3	204	23	211	333	64
Lady Finger	67	Cream: 1	95	17	132	178	76
Williams #1	76	Cream: 1	64	8	123	134	42
Williams #2	75	Cream: 1	50	7	93	104	33

a. High-performance liquid chromatographic (HPLC) analyses were conducted at the University of Newcastle in 2002. Samples were collected from May to June 2002 at the Queensland DPI&F field collection, South Johnstone Research Station, Australia, except for *Red Dacca* (Liverpool Creek grower) and *Wain* (East Palmerston grower). All were prepared as composite samples of 6 fingers each except *Sucrier*, for which 12 fingers were included in the sample.

b. Name of cultivar was recorded at the Queensland DPI&F field collection, South Johnstone Research Station, Australia. For some cultivars a sample was taken from two different bunches and analyzed separately (these specified as #1 and #2).

c. Cultivars are listed in order of greater to lesser all-*trans* β-carotene content.

d. Banana flesh color was described visually by comparing it with four colors from a paint company catalogue: 1–cream, 2–pastel yellow, 3–bright yellow, and 4–yellow/orange.

e. Content of all-*trans* β-carotene and *cis* β-carotene plus half the content of α-carotene.

Previous studies [40–43] (see **table 1**) found that *Pisang Raja Udang (*also called *Red Dacca)* and *Pisang Raja* (also called *Pisang Raja Buluh)* contained 417, 290, and 420 μg of β-carotene equivalents/100 g, respectively [26, 40], and *Ternate* (*Pisang Raja* subgroup) contained 325 μg of β-carotene equivalents/100 g [41], although it is not certain that these are the same cultivars as those analyzed in this study. An Indonesian study identified *Pisang Raja*, which means literally "banana king," as one of the 47 foods contributing most of the vitamin A to the diet of 265 preschool children [44]. *Pisang Raja* is an important commercial crop in Indonesia, well known as a hardy variety and described as one of Indonesia's fruit delights [45].

Previous studies found that *Tundok* and *Pisang Tandok,* both synonyms of *Horn Plantain*, had quite different carotenoid levels in different analyses (370 and 1,370 μg of β-carotene equivalents/100 g, respectively) [40, 41]. Analysis of three cultivars grouped as *Sucrier* (called *Kluai Khai* in Thailand, *Pisang Mas* in Malaysia, and *Kudud* in Pohnpei, Micronesia) found similar levels (345, 411, and 420 μg of β-carotene equivalents/100 g) [26, 40, 42]. These bananas have great cultural importance; for example, *Kluai Khai* is associated with a particular festival in one Thai province and is used in the offering dish that is presented to the monks at that time [46]. On a similar line, *Pisang Mas* is a cherished banana variety in Malaysia, well known for its small, sweet fruit.

To put the findings of this study into perspective, reference is made to the Micronesian study, in which 64 samples of 25 Micronesian banana cultivars were analyzed. In that study the level of β-carotene equivalents was > 300 μg/100 g in 18 cultivars and > 100 μg/100 g in 22 cultivars [24–26]. In general, for sets of samples prepared both cooked and raw, the cooked samples had higher carotenoid levels. This result has been found previously and has been explained by possible loss of moisture and the greater ease with which carotenoids are extracted from cooked samples [27].

Assessment of the impact of banana cultivars on estimated vitamin A requirements

Table 3 presents the RE content per cultivar in micrograms per 100 g along with the weight of fruit needed to meet at least half of the estimated requirements for a nonpregnant, nonlactating adult woman and a preschool child. All 10 tested cultivars contained significant levels of provitamin A carotenoids, meeting

TABLE 3. Comparison of selected ripe raw banana cultivars for impact on vitamin A intake in terms of recommended safe intake (RSI)

Local name of cultivar[a]	β-Carotene equivalents[b] /100 g	RAE[c] (μg/100 g)	RE[d] (μg/100 g)	Fruit weight needed to meet 50% of RSI for non-pregnant, nonlactating woman[e] (g)	Fruit weight needed to meet 50% of RSI for pre-school child[f] (g)
Asupina	1,554	130	259	97	77
Kirkirnan	1,089	91	182	137	110
Pisang Raja	976	81	163	153	123
Horn Plantain	946	79	158	158	127
Pacific Plantain	589	49	98	255	204
Kluai Khai Bonng	556	46	93	269	215
Wain	532	44	89	281	225
Red Dacca	367	31	61	410	328
Lakatan	354	30	59	424	339
Sucrier	333	28	56	446	357
Lady Finger	178	15	30	833	667
Williams	119	10	20	1,250	1,000

a. Name recorded at the Queensland DPI&F field collection, South Johnstone Research Station, Australia. Cultivars listed in order of greater to lesser β-carotene equivalent content.
b. Data from **table 2**. A mean was calculated of the β-carotene equivalents for which composite samples were taken from more than one bunch.
c. Retinol activity equivalents (RAE): conversion factor of 12:1 from β-carotene equivalents to RAE.
d. Retinol equivalents (RE): conversion factor of 6:1 from β-carotene equivalents to RE.
e. Calculated from the estimated recommended safe intake (RSI) for a nonpregnant, nonlactating adult woman, 500 μg RE/day [38].
f. Calculated from the estimated recommended safe intake (RSI) for a child 1 to 3 years old, 400 μg RE/day [38].

the estimated requirements for an adult woman within normal consumption patterns. In Pacific countries, the consumption of staple crops by adults has been estimated to be from 750 to 1,000 g per day, indicating that these cultivars could possibly also provide a much greater percentage of the daily requirements or all of the requirements for some people. The cultivar *Asupina* had the highest level of provitamin A carotenoids. The edible portion of one fruit weighed around 120 g after the peel was discarded (**table 1**) and would easily provide the estimated requirements for a nonpregnant, nonlactating adult woman.

Seven of the test cultivars (*Asupina, Kirkirnan, Pisang Raja, Horn Plantain*, *Pacific Plantain, Kluai Khai Bonng*, and *Wain*) can be considered excellent sources of provitamin A carotenoids. Consumption of less than 300 g of edible flesh of these cultivars (approximately three fingers, depending on cultivar and fruit size) could potentially provide half of the estimated vitamin A requirements for a nonpregnant, nonlactating adult woman. However, for markets where the aim is to have a more nutritious banana in terms of carotenoid content, any of the yellow- or yellow/orange-fleshed cultivars would be an improvement, since all 10 had more than twice the level of RE as *Cavendish*.

Correlations of carotenoid levels with fruit pulp color

Table 4 presents the flesh color for each cultivar as determined by HunterLab coordinates. Regression analysis of the mean values of each color coordinate and of the RAE for each cultivar showed that a highly significant correlation was found for the **a** value ($r^2 = 0.84$; $p < .001$, 10 df) with a linear relationshop of $y = 0.056x + 0.66$ (where y = color and x = RAE). Thus, an increase in RAE is highly correlated with increased redness of the fruit pulp. There was also a significant correlation between RAE and **b** ($r^2 = 0.43$, $p < .05$) and Chroma ($r^2 = 0.41$, $p < .05$), indicating that RAE was associated with increasing yellow color (**b**), the combination of red plus yellow (Chroma), although the strength of the relationship was not as consistent as for the **a** value**.** There was no significant correlation between RAE and L value ($r^2 = 0.11$) or hue angle ($r^2 = 0.05$).

Acceptability and other attributes of *Asupina* fruit

Table 5 presents data on the acceptability of *Asupina,* the test cultivar with the highest carotenoid levels. The taste panel participants, who had not previously seen or tasted *Asupina*, were generally enthusiastic about it and indicated that the appearance, texture, and taste were acceptable. The participants were not positive about the appearance of the skin, since there were blemishes, although this may be a factor that can be improved. Because the texture of *Asupina* flesh is so smooth, some suggested that it would not be considered as what is normally thought of as a banana, but that it would be excellent for mashing for infants or for use in fruit salad

TABLE 4. Comparison of selected ripe raw banana cultivars by HunterLab color coordinates

Local name of cultivar[b]	HunterLab color scale[a]			Chroma[f]	Hue angle[g] (degrees)
	Light to dark **L**[c]	Green to red **a**[d]	Blue to yellow **b**[e]		
Asupina	65.0	7.8	33.1	34.0	23
Kirkirnan	55.7	6.7	21.7	22.9	29
Pisang Raja	59.0	3.2	19.3	19.6	16
Horn Plantain	58.9	5.8	21.1	21.9	27
Pacific Plantain	65.4	4.8	20.7	21.3	22
Kluai Khai Bonng	61.7	3.3	19.2	19.5	17
Wain	65.9	2.8	33.0	33.1	8
Red Dacca	60.5	1.9	18.4	18.5	10
Lakatan	62.2	2.9	20.4	20.6	14
Sucrier	52.6	1.7	19.8	19.9	9
Lady Finger	60.1	1.4	17.5	17.5	8
Williams	60.4	1.0	15.3	15.4	7

a. Measurements were taken with a HunterLab colorimeter (Minolta Chroma Meter CR300).
b. Name recorded at the Queensland DPI&F field collection, South Johnstone Research Station, Australia. Cultivars listed in order of greater to lesser β-carotene equivalent content.
c. A measure of the level of light or dark (ranges from black with a value of zero at the bottom of the axis to white with a value of 100 at the top of the axis).
d. A measure of green to red, with a negative value for green and a positive value for red.
e. A measure of blue to yellow, with a negative value for blue and a positive value for yellow.
f. A measure ranging from –150 to 150 increasing outward from the lightness axis.
g. A measure ranging from 010° to 360° as arranged on pages on the color coordinate axis.

after removal of the skin. On the other hand, some participants pointed out that they might not purchase this cultivar because of lack of familiarity. The participants agreed that a good promotion campaign would be essential for marketing this cultivar in Australia or other regions where it is not a known banana cultivar.

Conclusions

This study confirms recent findings from other studies of Micronesian bananas [24–26] that ripe yellow- and yellow/orange-fleshed banana cultivars are carotenoid-rich, offering potential for alleviating vitamin A deficiency. All 10 tested Southeast Asia and Pacific Islands cultivars with yellow- or yellow/orange flesh contained nutritionally significant levels of provitamin A carotenoids and could potentially meet half or all of the estimated vitamin A requirements of a nonpregnant, nonlactating adult woman with normal consumption patterns. Because these cultivars are carotenoid-rich (far surpassing the common *Cavendish* banana), they could also be niche marketed in both industrialized and developing countries as functional foods and play a role in controlling chronic disease problems, including cancer, heart disease, and diabetes.

Because of the soft texture and sweetness of ripe bananas, their hygienic covering, and ease of preparation, bananas are very suited for young children, and carotenoid-rich varieties could potentially contribute significantly to vitamin A requirements in children.

The finding that the HunterLab **a** color coordinate (strong red color) was strongly correlated with the provitamin A content indicates that cultivars could initially be screened on the basis of the color of the fruit's flesh; those cultivars with a high **a** value could then be selected for chemical analysis. Furthermore, visual assessment of flesh coloration was a relatively good indicator of carotenoid content and could help people in the community to select cultivars with the greatest health benefits.

As far as we are aware, this is the first study to provide data on the carotenoid contents of *Asupina, Kirkirnan, Wain, Pacific Plantain*, and, probably, *Kluai Khai Bonng*. Since there are many yellow- and yellow/orange-fleshed banana and plantain cultivars existing throughout the world, with few data on their provitamin A content, a further systematic evaluation to identify acceptable carotenoid-rich cultivars with agricultural potential elsewhere may provide information of considerable health importance.

Acknowledgments

Warm thanks are extended to the staff and students of the University of Queensland, School of Population Health, Nutrition Program, who participated in the informal taste panel, and to Geoff Marks and Maureen Fitzgerald for advice on this paper.

TABLE 5. Responses of an informal taste panel (n = 10) to selected questions about the acceptability of *Asupina* banana[a]

Question[b]	Yes—no. (%)	No—no. (%)	NA[c]—no. (%)	Recorded responses[d]
Appearance of the fruit Is it attractive?	2 (20)	8 (80)	0 (0)	There are many blemishes, black marks on the [unpeeled] finger It doesn't look like a usual banana, it takes time to get used to it It is not attractive because it is unfamiliar It is not attractive but it is interesting The outside isn't attractive but the color of the flesh is…because it is orange and a bright color The flesh color is very attractive, great for fruit salads and fruit platters It is beautiful. The flesh doesn't go brown when peeled
Texture of the fruit Do you like the texture?	8 (80)	1 (10)	1 (10)	The texture is good for mashing for babies It would be excellent for frying
Taste of the fruit Is it sweet?	6 (80)	3 (10)	1 (10)	It is not so sweet and would be good with a cheese platter, in salads, and on breakfast cereals It is not as sweet as *Lady Finger* but has a similar flavor It has a starchy edge Lovely flavor It is not so sweet, but I like it
Marketing potential Would you buy this at a shop if it was priced the same as another?	7 (70)	3 (30)	0 (0)	I would definitely buy it, I would prefer it No, I would not buy it for myself unless my family had tried it and liked it It has a great flavor, but I would not use it in place of existing bananas, it is different…the texture is soft

a. The taste panel session was held April 22, 2002, from 10 to 11 A.M., at the University of Queensland, School of Population Health, Brisbane, Australia, with Nutrition Program staff and students, including seven Australians and three others. No participants had previously seen or tasted *Asupina,* which was brought to Australia from Papua New Guinea as part of a collecting mission by the International Board for Plant Genetic Resources. The fruits were harvested from the Queensland DPI&F field collection at South Johnstone Research Station, Australia, and sent by post to Brisbane for the taste panel session.

b. All questions were presented on individual structured questionnaire forms.

c. Not applicable; one participant did not respond to all questions because she had an allergy to banana and did not taste it.

d. All responses were self-recorded without discussion among participants.

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Iodine deficiency persists in the Zanzibar Islands of Tanzania

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Commentary

Tanzania has, over the past decade, made good progress toward universal salt iodization, but the most recent information and data reported by the World Health Organization (WHO) and UNICEF, and published in the regular "scorecard" of progress by the Network for Sustained Iodine Nutrition (http://206.191.51.240/Resources_Nutrition.htm), indicates that only 73.8% of households have access to iodized salt. Moreover, only 67% of the accessible salt is satisfactorily iodized to optimal levels. However, Tanzania has a functioning National Committee, appropriate legislation is in place, and a national officer responsible for salt iodization has been appointed. The country has also committed to assessing national progress in iodization coverage at least every five years.

The study by Assey et al. confirms the well-known fact that populations living on islands or near seacoasts are not free from iodine-deficiency disorders. It has long been known that such populations are in need of daily intake of iodine. Nor are iodine-deficiency disorders limited to developing nations; they are a danger wherever iodine has been depleted from the soil. The most economic, efficient, and effective method of delivering iodine to the population every day in every village is via iodized salt.

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Abstract

Background. *Iodine is an essential micronutrient for normal human growth and development. It is estimated that more than 1.6 billion people live in iodine-deficient environments, yet there are still some countries and areas where the prevalence of iodine-deficiency disorders is unknown.*

Objective. *To establish the prevalence of iodine-deficiency disorders in the Zanzibar Islands, a community assumed to have ready access to iodine-rich seafoods.*

Methods. *In a cross-sectional study, 11,967 schoolchildren were palpated for goiter prevalence, a subsample was evaluated for urinary iodine concentration, and the availability of iodated salt was assessed at the household and retail levels.*

Results. *The mean total goiter prevalence was 21.3% for Unguja and 32.0% for Pemba. The overall median urinary iodine concentration was 127.5 µg/L. For Unguja the median was 185.7 µg/L, a higher value than the median of 53.4 µg/L for Pemba ($p < .01$). The household availability of iodated salt was 63.5% in Unguja and 1.0% in Pemba. The community was not aware of the iodine-deficiency problem and had never heard of iodated salt.*

Conclusions. *The inadequate intake of iodine documented in the Zanzibar Islands belies the common assumption that an island population with access to seafood is not at risk for iodine-deficiency disorders. We urge health planners to implement mandatory salt iodation and education efforts to alleviate the situation.*

Key words: Goiter prevalence, iodated salt, iodine deficiency, Tanzania, urinary iodine, Zanzibar

Introduction

Iodine is an essential micronutrient for normal human health and development. It is found in the soil and seawater and is transferred to humans through the food chain. Iodine deficiency is characterized by a slowdown of metabolic processes, which in children translates into a deficit of growth and development [1, 2]. The World Health Organization (WHO) estimates that more than 1.6 billion people live in iodine-deficient environments [2, 3]. These environments are in highlands and flood-prone areas where the soil becomes iodine deficient as a result of erosion and leaching. In 1999, WHO/UNICEF/ICCIDD classified 130 of 191 countries as having iodine-deficiency disorder problems, 20 as having eliminated the problem, and the remainder as having an unknown level of iodine-deficiency disorder problems [4].

On the basis of a large series of local and district goiter surveys conducted among schoolchildren in 1980–90 in mainland Tanzania, about 10 million people were estimated to be at risk for iodine-deficiency disorders, and an estimated 5.6 million people were suffering from endemic goiter [5]. Interventions undertaken since the mid-1980s included large-scale oral iodine supplementation and universal salt iodation [6]. Recent iodine-deficiency disorder evaluation survey reports from 16 endemic districts showed a substantial increase in the consumption of iodated salt and a concomitant reduction in goiter prevalence [7].

Zanzibar, consisting of the islands of Unguja and Pemba, with a total area of 2,332 km^2, is part of the United Republic of Tanzania* (**fig. 1**). Zanzibar was not covered by goiter surveys and interventions conducted by the Tanzania Food and Nutrition Centre (TFNC), because it was assumed that populations surrounded by ocean have adequate iodine status from the consumption of seafood such as fish, crabs, snails, and sea plants rich in iodine [1, 8].

In 1998, 31 goiter cases were reported from Zanzibar after screening for visible goiter in Pemba South District; 84% of the patients were women.** This report alerted the TFNC to the need for a formal assessment in both islands. The present study was designed to establish the prevalence of iodine deficiency in the Zanzibar Islands and to identify possible etiological factors. As far as we know, this is the first study of iodine deficiency in the Zanzibar Islands.

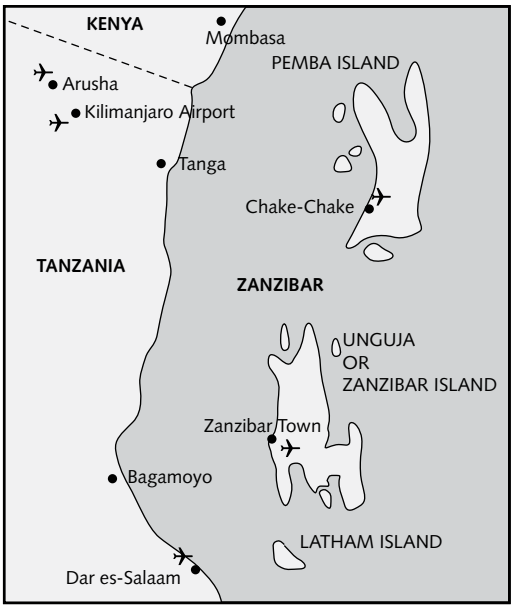

FIG. 1. Map of Zanzibar showing the islands of Unguja and Pemba

Subjects and methods

Study area, population, and sample size

This cross-sectional study was conducted on the two islands of Zanzibar, Unguja and Pemba, and covered primary schoolchildren from 10 districts. All primary schools on the islands were allocated to one of three stratified geographic divisions described by local residents as highlands, lowlands, and townships. Such strata are known to be related to iodine status [1]. In each of the 10 districts, two schools were randomly selected for each stratum, resulting in a total of 60 schools surveyed. Since this was a baseline survey, three major iodine-deficiency disorder indicators were assessed to reflect the magnitude of the problem—goiter prevalence, urinary iodine concentration, and household availability of iodated salt—as a basis for planning future interventions and evaluating their impact. In each school, 200 children were systematically selected on the basis of the proportional number of children in each class and were palpated for goiter [9]. A subsample of 10 children from each school was systematically selected at 1/20th interval of sample children (i.e., every 20th child was selected) to give urine samples for determination of urinary iodine concentration levels [9, 10]. To determine the availability of iodated salt at the household level, one child

* The United Republic of Tanzania is a union of two governments (Tanzania Mainland and Zanzibar) with some independent ministries for each government, such as Health and Social Welfare. The health priorities of the different ministries are not necessarily the same.

** Government of Zanzibar. Speech by the Minister of Health to the Revolutionary Council of the House of Representatives, Zanzibar, July 1999.

from each household brought a tablespoonful of salt for iodine testing and was also asked about his or her awareness of iodated salt.

Shops selling salt were also assessed for the presence of iodated salt, with a convenience sample of 5 to 10 shops for each of the 10 districts. In addition, in each village with a school that had been selected for the goiter survey, shopkeepers were interviewed and community members participated in a group discussion. A convenience sample of 80 salt samples was collected from shops and analyzed for iodine content.

Knowledge, attitudes, and practices relating to iodine-deficiency disorders and iodated salt were assessed among the shopkeepers and the community members. A semistructured questionnaire was used to collect data from the shopkeepers. Focus group discussions were conducted in a convenience sample of adult members of the community with the use of a discussion guide.

Iodine status measurement procedures

Goiter assessment was performed to measure the long-term iodine status of the population. Primary schoolchildren were chosen as the group to measure, as is commonly done in goiter surveys. An experienced medical nutritionist palpated and graded goiters according to the WHO goiter classification criteria of Perez and Scrimshaw [11, 12], which offers increased specificity [13], and also allow for a more direct comparison to previous surveys conducted in Tanzania [5]. Children were classified as having goiter if the thyroid size was of grade 1a, 1b, 2, or 3; a palpable goiter was defined as grade 1a when one lobe was deemed larger than the terminal phalanx of the child's thumb [11, 13].

Urinary iodine concentration levels were determined by the Sandell-Kolthoff reaction using the spectrophotometric ammonium persulfate digestion method with a lower limit of detectability of 0.0034 μg of iodine. A coefficient of variation of less than 5% was obtained, which compares well with the inductively coupled plasma mass spectrometric (ICP-MS) method that aims for a coefficient of variation less than 10% [10, 14].

Salt samples from the households were tested semi-quantitatively in the presence of the child using a rapid test kit for iodate (MBI Kit) that causes the color of the salt to change to blue if the iodine content is 15 ppm or more. Salt samples from shops were assessed for iodine levels by the iodometric titration method [10, 15].

Data analysis

The qualitative data were analyzed by content analysis, whereas the quantitative data were analyzed by SPSS (version 10). Mean ± SD and median values were calculated for continuous data and frequencies for categorical data.

Ethical approval and informed consent

The study proposal was approved by the Ministry of Health and Social Welfare Committee on Research on Human Subjects. Two of the authors explained the purpose and requirements of the study to the children, primary schoolteachers, and community members. Only those children and community members who gave informed consent participated in the study. Fifty children declined to participate.

Results

Sample characteristics

Information on goiter prevalence was collected from 11,967 children: 7,101 from Unguja and 4,866 from Pemba. The average age was 12 years (range, 6 to 18 years), and 48.9% were male.

Goiter prevalence

Table 1 provides data on goiter palpation results, urinary iodine concentration, and availability of iodated salt at the household level by district for the two islands. In Unguja, where the land is mostly flat, 3.8% of children had visible goiter and the total goiter prevalence was 21.3%. In Pemba, which is made up of hills and escarpments, 8.8% had visible goiter and the total goiter prevalence was 32.0%. These results indicate the presence of a moderate iodine-deficiency disorder problem on Unguja and a severe problem on Pemba [9]; the environmental influence on iodine deficiency was more obvious in Pemba than in Unguja.

The relations between goiter grades 1a and 1b and visible goiter were different in the two islands. In Pemba, thyroid size was larger, as indicated by a high prevalence of visible goiter and a higher prevalence of grade 1b goiter than of 1a goiter. Goiter prevalence was

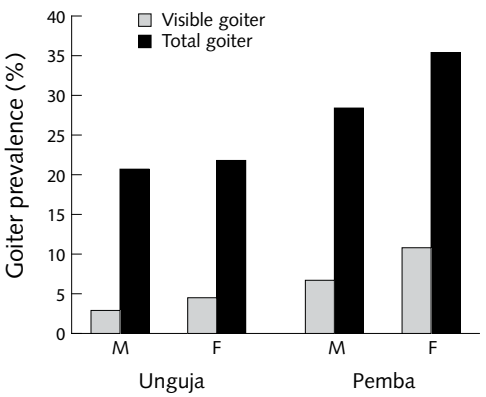

FIG. 2. Goiter prevalence among male and female schoolchildren in Unguja and Pemba Islands

TABLE 1. Indicators of iodine deficiency among primary schoolchildren in districts in the islands of Zanzibar[a]

District	No. of children sampled	Goiter prevalence (%)				Urinary iodine		Availability of iodated salt	
		Grade 1a	Grade 1b	Visible goiter[b]	Total goiter[c]	Samples analyzed	Median (μg/L)	No. of households sampled	% with iodated salt
Unguja Island									
Urban	1,206	7.4	5.6	2.0	15.0	58	282.5	1,641	65.1
West	1,201	6.9	6.2	3.2	16.3	59	218.0	1,041	57.5
Central	1,165	7.0	6.6	3.6	17.2	58	173.9	1,346	65.9
South	1,175	13.6	11.6	3.5	28.7	58	204.9	1,031	51.0
North A	1,208	11.1	10.4	4.6	26.1	65	185.6	1,513	69.4
North B	1,145	9.3	10.1	5.7	25.1	58	121.6	758	66.5
Total	7,101	9.2	8.3	3.8	21.3	356	185.7	7,330	63.5
Pemba Island									
Wete	1,205	13.8	14.8	7.9	36.5	57	63.4	1,890	0.7
Micheweni	1,226	9.5	13.4	8.7	31.6	58	35.1	2,041	0.2
Chakechake	1,224	10.0	11.7	9.6	31.6	47	75.7	2,396	2.0
Mkoani	1,211	8.1	11.6	9.1	28.8	41	50.8	2,167	0.9
Total	4,866	10.3	12.8	8.8	32.0	202	53.4	8,494	1.0
Zanzibar total	11,967	9.6	10.2	5.8	25.6	559	127.5	15,824	30.0

a. Unguja and Pemba Islands are collectively known as Zanzibar.
b. Visible goiter consists of grades 2 and 3 goiter.
c. Total goiter consists of grades 1a, 1b, 2, and 3 goiter.

higher among girls than among boys (**fig. 2**). The sex-related difference in prevalence was more pronounced on Pemba. For Zanzibar as a whole, the prevalence was highest in the 13-to-15-year age group ($p < .05$) (**table 2**).

Urinary iodine concentration

There was a significant difference in urinary iodine levels between Unguja and Pemba ($p < .01$) (**table 1**). The mean values for Unguja and Pemba were 215 ± 145 and 79 ± 80 μg/L, respectively; the mean difference was 136 μg/L (95% confidence interval, 114.5 to 157.8). The median urinary iodine concentration for Unguja was 186 μg/L, and no district had a median value of less than 100 μg/L, the cutoff value for mild iodine deficiency. In Pemba, the median urinary iodine concentration was 53 μg/L (district range, 35 to 76 μg/L), indicating moderate iodine deficiency. The proportion of children with urinary iodine concentrations below 50 μg/L was only 8% in Unguja ($n = 356$) but was 47% in Pemba ($n = 203$). The overall median urinary iodine concentration was higher in boys (139 μg/L, $n = 283$) than in girls (113 μg/L, $n = 176$) ($p < .01$).

Salt iodine content

The findings from 15,824 salt samples from households in 10 districts tested qualitatively for iodine are also presented in **table 1**. Of the 7,330 samples from Unguja, 63.5% had adequate iodine, in comparison with 1.0% of 8,494 samples from Pemba ($p < .01$).

Of 121 salt traders surveyed (81 from Unguja and 40 from Pemba), 58.7% in Unguja and 3.3% in Pemba were selling iodated salt, most of which originated from the Tanzanian mainland. Most of the salt consumed in both islands was coarse salt that was packed in bulk in 50-kg bags without inner linings and sold in the open. This mode of packaging probably increased the loss of iodine from iodated salt. Other salt had been imported by individual salt traders from neighboring countries and was sold nonbranded in retail shops.

Quantitative analysis of the iodine content of 80 salt samples from shops found that iodine levels were very low in comparison with the national retail level requirement of ≥ 37.5 ppm iodine used in mainland Tanzania (**table 3**); the median iodine content was 10.3 ppm ($n = 56$) for Unguja and 2.9 ppm ($n = 24$) for Pemba. Thus, 66% and 79% of all salt samples tested in Unguja and Pemba, respectively, had unacceptably low levels of iodine, whereas 3.7% of samples for Zanzibar as a whole were overiodated (> 100 ppm iodine).

None of the children examined for goiter, and none of the community members, including schoolteachers, had heard of the iodine-deficiency problem or were aware of iodated salt. None of the wholesalers or retail traders were aware of the iodine-deficiency problem. Very few reported ever having heard of iodated salt, despite the fact that many shops in Unguja were stocked with salt labeled "iodated." Fine-ground salt was commonly used in restaurants and by street vendors selling snacks, presumably because it is easier

TABLE 2. Prevalence of goiter in Zanzibar according to age group

Age (yr)	No. of children sampled	Goiter prevalence (%)			
		Grade 1a	Grade 1b	Grades 2 and 3	Total goiter
6–12	6,721	8.1	6.6	3.3	18.1
13–15	4,381	12.3	15.2	9.3	36.9
≥ 16	865	8.0	12.0	7.2	27.2
Total	11,967	9.6	10.2	5.8	25.6

TABLE 3. Proportion (%) of salt samples from shops in Unguja and Pemba islands with unacceptable, low, acceptable, and high levels of iodine[a]

Island	No. of samples	Unacceptable	Low	Adequate	High
Unguja	56	66.1	21.4	8.9	3.6
Pemba	24	79.2	4.2	12.5	4.2
Zanzibar total	80	71.2	15.0	10.1	3.7

a. Levels are defined by the United Republic of Tanzania Salt Acts: Mining Act, 1979; Mining Regulation, 1994 (salt production and iodation); Food Act, 1978 (control of quality); Control of Quality Regulation, 1992 (iodated salt). Unacceptable levels are defined as 0.0–18.4 ppm, low levels as 18.5–37.4 ppm, acceptable levels as 37.5–100.0 ppm, and high levels as > 100.0 ppm.

to use than coarse salt. This type of salt is not locally processed but is imported from neighboring countries and is probably iodated. It was also observed that fishing was very common in the islands.

The main food crops were cassava, rice, vegetables, and a variety of fruits. Cloves and coconuts were the major commercial crops. Seaweed was also produced in some areas for export but was not consumed locally.

Discussion

This study was cross-sectional, offering a snapshot of a dynamic situation in which iodated salt from mainland Tanzania may occasionally be available, leading to temporary improvements in iodine status among those who consume it, but most salt probably continues to come from local non-iodated sources in the absence of legislation requiring salt iodation in Zanzibar.

Quantitative measurements of the iodine content of salt samples from shops on both islands found an overall median value below 18 ppm, the minimum required at the household level in mainland Tanzania.* Pemba is almost solely dependent on its locally produced salt. Its small-scale producers had no knowledge of iodine-deficiency disorders or of salt iodation. The few brands of imported iodated salt were often not marked so that they could be distinguished from local salt samples. They may also have had low levels of iodine as a result of losses from poor handling and storage. The producer education efforts directed to mainland Tanzania [5] were not implemented in Pemba.

Unguja Island, where the main port of Zanzibar is located, has better access to commercial goods and imports much of its salt from countries that have been implementing salt iodization programs for almost a decade. Some of the salt originating from the coastal belt of mainland Tanzania, however, was found not to be iodated, presumably because there was no demand for iodation from Zanzibar.* This allows salt producers to avoid the extra labor required for iodation and also to save their potassium iodate for those buyers who demand iodated salt.

At the moment, none of the indicators listed by WHO for achieving sustainable elimination of iodine-deficiency disorders is fulfilled in Zanzibar [9]. On the basis of total goiter prevalence alone, Zanzibar suffers from a moderate iodine-deficiency disorder problem, presumably caused by lack of adequate dietary iodine intake. The reliability of goiter data can be questionable. There may be intraobserver and interobserver variability in the data [9], but this variability was probably reduced by using one experienced examiner and the WHO goiter criterion [13]. However, goiter prevalence may not reflect current iodine status very well in a situation like that on the Zanzibar Islands, where imported iodated salt may have been available at times [9]. In such a situation, measurement of urinary iodine concentration provides important complementary information [10]. According to WHO, median iodine concentrations should be greater than 100 μg/L in "non-iodine-deficient" populations, and no more than 20% of the population should have a urinary iodine concentration of less than 50 μg/L [9, 16]. These

* The following acts of the United Republic of Tanzania affect the production and quality of salt: Mining Act, 1979; Mining Regulation, 1994 (salt production and iodation); Food (Control of Quality) Act 1978; Control of Quality (iodated salt) Regulation, 1992.

criteria were met in Unguja but not in Pemba, where 47% of urine samples had an iodine concentration of less than 50 μg/L.

Pemba has a higher average altitude than Unguja and a higher goiter rate. Increased rates of iodine-deficiency disorders with increased altitude have been observed elsewhere [1]. However, in this case the lower penetration of iodated salt in Pemba probably explains the difference. Furthermore, even when iodated salt is occasionally available, it is likely to be more available and affordable in towns than in more isolated areas.

As is commonly seen for iodine-deficiency disorders [17], females were more affected than males, particularly in Pemba. The large differences observed between the sexes might not have been expected if, as assumed, the population consumed adequate quantities of iodine-rich seafoods. In addition to a possible physiological explanation, with women having higher iodine demands, males may take more meals or eat more snack foods outside the home, where iodated salt may have been used in food preparation or may be available on restaurant tables. In the culture of Zanzibar, older girls, like their mothers, tend to remain indoors and thus are less likely to consume iodated salt outside the home. As girls begin to bear children, there is a risk of fetal and neonatal deficiencies, which can lead to brain damage from iodine deficiency [17–19]. This calls for special iodine surveys targeting women of childbearing age [20].

The low median urinary iodine levels in Pemba suggest low dietary intake of iodine from the foods locally consumed. This finding is similar to those from some Pacific islands [21, 22]. Thus, assumptions should not be made about the iodine status of populations living close to the sea. In this case, iodated salt may be the only sustainable alternative for improving the population's iodine status, since salt is the only processed food item consumed daily by most islanders.

Goiter prevalence levels were high on both islands, although urinary iodine levels were normal in Unguja but not Pemba. This is to be expected, because goiter levels take many years to normalize once iodine intakes increase after long periods of being suboptimal [9, 12]. In Unguja, the availability of iodated salt as an opportunistic intervention has presumably occurred recently, probably as a result of the effective implementation of an iodine-deficiency disorder control program in mainland Tanzania.

Goiter can also be caused by food rich in goitrogens, such as bitter cassava. Cassava increases the level of thiocyanate, the end product of cyanide detoxification in the human body, which has been shown to competitively interfere with iodine uptake in the thyroid gland in experimental studies [23, 24]. However, even populations with very high dietary thiocyanate intake from insufficiently processed cassava do not develop goiter if iodine intake is adequate [25, 26]. Although people in Zanzibar consume cassava, we do not know the extent to which this may contribute to the prevalence of goiter on the islands. The low urinary iodine concentrations observed in the high-goiter areas suggest that cassava is not a major contributing factor.

Another possible contributing factor to the etiology of the iodine-deficiency disorder problem in Zanzibar is iron-deficiency anemia. On Pemba Island, the prevalence of anemia among children was found to be 62.5%, of which 51.5% was due to iron deficiency [27]. It has been suggested that concurrent iron-deficiency anemia impairs the therapeutic response to iodine supplementation, possibly as a result of decreased conversion of thyroxine (T_4) to triiodothyronine (T_3) or through decreased thyroperoxidase activity, impairing iodide organofication [28, 29]. Thus, iron deficiency is associated with a high prevalence of goiter [30].

The endemic goiter seen on both islands shows that access to seafood has not protected the population against iodine-deficiency disorders, although such protection has often been assumed [1, 8, 12]. Although the islands of Zanzibar are small and have a high rainfall, the amount of iodine brought to the soil by rain may be smaller than the requirement; hence, no natural correction can take place and iodine deficiency is likely to persist indefinitely [1]. Measures for combating iodine deficiency required in these islands include raising public awareness, ensuring easy access to iodated salt, and promoting compliance with iodation in the salt industry by legislating mandatory iodine fortification of all salt, as well as monitoring and enforcement of the legislation [31]. We urge health and nutrition program planners not to assume, as we did, that iodine deficiency is not a public health problem in islands; only iodine-deficiency surveys can determine whether this problem exists.

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* The Government of Zanzibar has no salt iodation regulation, which is widely considered to be mandatory for iodine-deficiency disorder control programs [9].

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The association between stunting and overweight in Latin American and Caribbean preschool children

Pablo Duran, Benjamin Caballero, and Mercedes de Onis

Abstract

Background. *Although some segments of the population continue to suffer from undernutrition, other groups exhibit excess weight gain, resulting in the coexistence of undernutrition and obesity and leading to a dual nutritional burden.*

Objective. *To explore the association between stunting and overweight in preschool children from Latin American and Caribbean countries.*

Methods. *We analyzed cross-sectional data from children 0 to 5 years of age from 79 nationally representative surveys, compiled by the World Health Organization (WHO) Global Database on Child Growth and Malnutrition. This database defines stunting as low height-for-age and overweight as high weight-for-height. These variables were explored with the use of simple and multiple regression models.*

Results. *There were significant differences between subregions in the prevalence of stunting: the prevalence was 7.4% in the Caribbean, 11.3% in South America, and 20.4% in Central America (*$p < .001$*). In contrast, the estimated prevalence of overweight was similar between subregions. The overall prevalence rates of stunting and overweight in Latin America and the Caribbean in the year 2000 were 13.7% and 4.3%, respectively. We found an inverse relationship (*$r = -0.3$*) between the prevalence rates of overweight and stunting, overall and within subregions. South America exhibited the highest slope and intercept on the regression of overweight on stunting.*

Conclusions. *Different subregions of Latin America and the Caribbean have different prevalence rates of childhood stunting but similar prevalence rates of overweight. There is an inverse relationship between stunting and overweight. The South American subregion had the highest increase and prevalence of overweight of the Latin American region.*

Key words: Body height, body weight, Caribbean, child, child growth, child malnutrition, epidemiology, infant nutrition, Latin America, nutrition survey, obesity, preschool

Background

Childhood malnutrition is a general term that encompasses both insufficient longitudinal growth (stunting) and inadequate weight. Chronic malnutrition is characterized by reduced height-for-age (stunting) and remains a worldwide public health problem, in spite of the modest but consistent improvements in health status and infant mortality over the past decades.

The prevalence rates of malnutrition and its predictors vary across populations and geographic regions. The estimated prevalence of underweight among preschool children in 2005 ranged from 5% in Latin America and the Caribbean to 25% in Asia [1]. Linear growth retardation is still highly prevalent in developing countries, but between 1980 and 2000 the prevalence decreased from 40.5% to 35.2% in Africa, from 60.8% to 43.7% in Asia, and from 25.6% to 12.6% in Latin America and the Caribbean [2].

Conversely, the prevalence of overweight has been increasing globally, and experts have warned of a global epidemic of obesity, affecting both developed and developing countries [3–7]. The estimated global prevalence of overweight among preschool children in developing countries was 3.3% in 1995; with Latin America and the Caribbean having the highest prevalence (4.4%). Latin America and the Caribbean has

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undergone a rapid epidemiologic and nutritional transition and has better economic and health conditions than other developing regions [4]. The consequent changes in dietary patterns and lifestyle may explain the increasing trends toward overweight and obesity in the region.

The interrelationships among socioeconomic conditions, food availability, and growth and body weight are complex. Although some segments of the population continue to suffer from undernutrition, other groups exhibit excess weight gain, resulting in the coexistence of undernutrition and obesity, even within the same household, representing a dual nutritional burden [8]. The possible mechanisms for the effect of undernutrition on obesity risk have been reviewed elsewhere [9] and include metabolic "programming" of appetite and energy balance regulatory systems by early nutrient deprivation, as well as environmental factors [10–12].

The objective of the present study is to analyze the association between the prevalence rates of stunting and overweight in Latin American and Caribbean preschool children and to describe differences within the region based on an ecological approach.

Methods

Cross-sectional data on the prevalence of stunting or low height-for-age (below –2 SD of the National Center for Health Statistics/World Health Organization [NCHS/WHO] reference population median) and overweight or high weight-for-height (above 2 SD of NCHS/WHO reference population median) in children aged 0 to 5 years were obtained from the *WHO Global Database on Child Growth and Malnutrition* [13]. The present analysis included 79 population-based surveys conducted at the national or subnational level between 1975 and 2002 from 24 countries (6 in the Caribbean subregion, 7 in the Central American subregion, and 10 in the South American subregion).

The unit of analysis corresponded to each age group (yearly or smaller intervals) from each survey, resulting in a total of 465 data points. Countries were grouped by subregions (Caribbean, Central America, and South America) according to the United Nations country classification [14].

Data on the prevalence rates of stunting and overweight were analyzed according to subregion, country, year of the study, and age group. The per capita gross domestic product (GDP) in the year prior to the study was also included for each data point. The data were taken from the United Nations database [15].

The methods used to obtain standardized country prevalence rates of stunting and overweight have been described elsewhere [16, 17]. The association between stunting and overweight was assessed by linear regression analysis from data for the whole time period and selected data points collected since 1990. Overweight was included as a dependent variable, and year of the study was included as a control variable. The analysis was performed for Latin America and the Caribbean as a whole and by subregion. Data management and data analysis were performed with SPSS version 10.0 and SYSTAT version 7.0.

Results

Table 1 shows the estimated prevalence rates of stunting and overweight in children aged 0 to 5 years, presented as percentages and total numbers of children, for Latin America and the Caribbean and its subregions in the year 2000. Although there are significant differences between subregions in the estimated prevalence of stunting, which ranges from 7.4% in the Caribbean to 20.4% in Central America ($\chi^2 = 85.2$, $p < .001$), the estimated prevalence of overweight is similar ($\chi^2 = 0.47$; $p = .79$) in different subregions.

Trends in the prevalence of stunting and overweight differ within the region (**fig. 1**). The prevalence of stunting shows a negative trend in the Caribbean and South America, but not in Central America. The estimated change (β coefficient) per 10 years in the prevalence of stunting according to linear regression analysis is –2.8% in the Caribbean and –5.9% in South America (standardized coefficients, –0.21 and –0.31), and 2.5% in Central America (standardized coefficient, 0.10). On the other hand, trends in the prevalence of overweight differ between subregions. No change (β coefficient) can be observed in the Caribbean (0.06%), but in Cen-

TABLE 1. Prevalence of stunting and overweight among children 0 to 5 years of age in Latin America and the Caribbean in 2000

	Stunting		Overweight	
Subregion or region	% (95% CI)	Millions (95% CI)	% (95% CI)	Millions (95% CI)
Caribbean subregion	7.4 (3.8–14.1)	0.3 (0.1–0.5)	4.1 (2.7–6.1)	0.14 (0.10–0.22)
Central American subregion	20.4 (12.5–31.5)	3.3 (2.0–5.1)	3.9 (2.8–5.4)	0.6 (0.5–0.9)
South American subregion	11.3 (6.5–18.9)	4.0 (2.3–6.7)	4.5 (3.5–5.9)	1.6 (1.2–2.1)
Latin America and the Caribbean region	13.7 (9.1–18.4)	7.6 (5.0–10.2)	4.3 (3.5–5.2)	2.4 (1.9–2.8)

CI, confidence interval

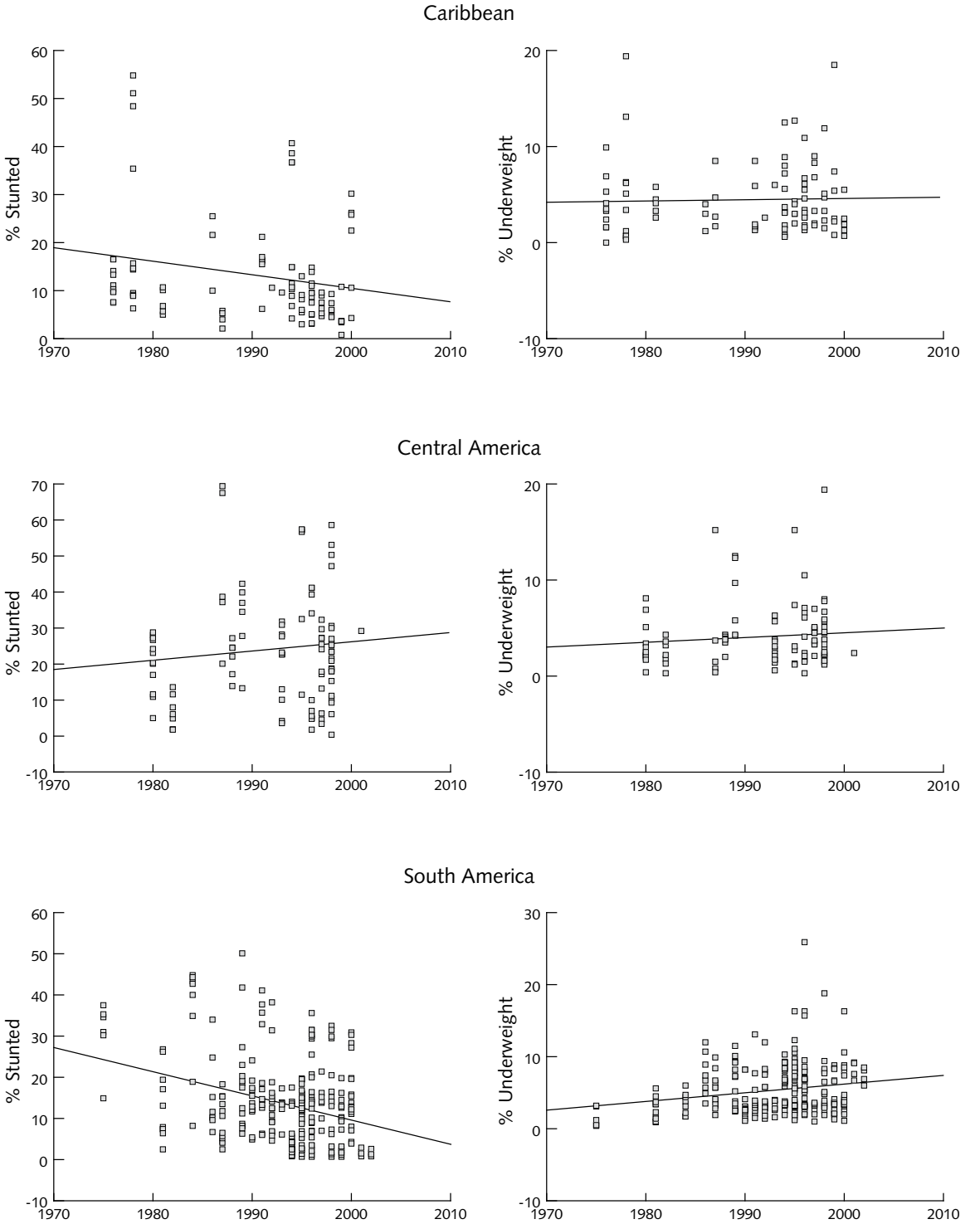

FIG. 1. Trends in the prevalence of stunting and overweight among children aged 0 to 5 years in Latin America and the Caribbean from 1975 to 2002 according to subregion (Selected surveys from WHO Global Database on Child Growth and Malnutrition)

tral and South America the estimated changes over 10 years were 0.5% and 1.3%, respectively.

An increased prevalence of overweight is observed even in studies that find a high prevalence of stunting. Most surveys (94.7%) that showed a low prevalence of stunting (< 2.3%) also showed a prevalence of overweight (weight-for-height > 2 SD) above 2.3%, and 77.7% of the surveys that showed a high prevalence of stunting (> 2.3%) also showed a prevalence of overweight (weight-for-height > 2 SD) above 2.3%.

An inverse correlation exists between stunting and overweight ($r = -0.3$) in the three subregions (**fig. 2**). The results of the regression analysis of overweight on stunting by subregions from Latin America and the Caribbean are presented in **table 2**. South America shows the highest value for the intercept, indicating a higher prevalence of overweight when the prevalence of stunting is equal to 0. The slope is similar for the Caribbean and South America and slightly lower for Central America. Similar results were obtained after adjustment for the year of the study.

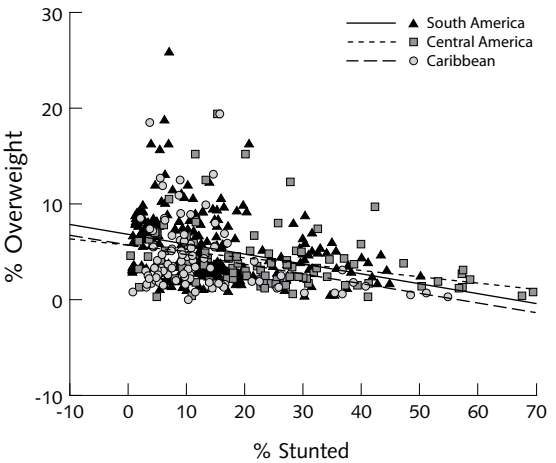

FIG. 2. Correlation between stunting and overweight in Latin America and the Caribbean among children aged 0 to 5 years according to subregion (Selected surveys from WHO Global Database on Child Growth and Malnutrition)

TABLE 2. Regression analysis of prevalence of overweight against prevalence of stunting among children 0 to 5 years of age in subregions of Latin America and the Caribbean. Selected surveys from WHO Global Database on Child Growth and Malnutrition

Subregion	*r*	α	β	SE (β)	*p*
Caribbean	0.296	5.7	–0.1	0.03	.004
Central America	0.306	5.6	–0.06	0.02	.002
South America	0.313	6.7	–0.1	0.02	.000

The prevalence of overweight has a higher variability when the prevalence of stunting is below 20%. For the Latin American and Caribbean region as a whole, the correlation coefficient is higher ($r = -0.28$, $p < .001$) in the subgroup with a prevalence of stunting above 20% than in the subgroup with a low prevalence ($r = -0.20$, $p < .001$). When the same analysis was stratified by subregion, a significant correlation between the prevalence of stunting and the prevalence of overweight in the three subregions could be observed in the subgroup with a prevalence of stunting above 20%. Only the data from South America show a significant association between stunting and overweight in the subgroup with a low prevalence of stunting (**table 3**). No differences between subgroups were observed when the analysis included only data from cross-sectional surveys conducted since 1990.

Per capita gross domestic product (GDP) was inversely correlated with the prevalence of stunting ($r = -0.46$, $p < .001$) and positively correlated with the prevalence of overweight, although with a smaller correlation coefficient ($r = 0.26$, $p < .001$). The coefficient of correlation of per capita GDP with the prevalence of overweight was higher in Central America ($r = 0.296$, $p < .003$) than in the Caribbean ($r = 0.215$, p

TABLE 3. Regression analysis of prevalence of overweight against prevalence of stunting according to prevalence of stunting among children 0 to 5 years of age in subregions of Latin America and the Caribbean. Selected surveys from WHO Global Database on Child Growth and Malnutrition

Stunting prevalence	*r*	α	β	SE β	*t*	*p*
Caribbean						
< 20%	0.07	4.374	0.065	0.104	0.620	.537
> 20%	0.57	3.409	–0.055	0.022	–2.537	.025
Central America						
< 20%	0.03	4.998	0.021	0.109	0.195	.846
> 20%	0.26	5.234	–0.056	0.028	–2.046	.045
South America						
< 20%	0.33	7.488	–0.201	0.039	–5.202	.000
> 20%	0.32	8.103	–0.124	0.054	–2.291	.027

< .03) or South America ($r = 0.205$, $p < .001$). On the other hand, the coefficient of correlation of per capita GDP with the prevalence of stunting was higher in the Caribbean ($r = 0.62$, $p < .001$) than in South America ($r = 0.49$, $p < .001$) or Central America ($r = 0.24$, $p < .017$). When per capita GDP and prevalence of stunting were included in the regression model analysis as independent variables, only the latter showed a significant β coefficient (–0.09, SE = 0.04 and 0.02) for the Caribbean and South America. For Central America, both the prevalence of stunting and per capita GDP were significantly correlated with each other, where the model can be expressed as

$$\text{Overweight} = 4.1 + 0.0008 \text{ per capita GDP} - 0.05\% \text{ stunting} + \text{error}.$$

Thus, even when GDP is associated with the prevalence of overweight, this relationship is not similar in the three subregions.

Discussion

Our study found significant differences in the prevalence of stunting among the subregions in Latin America and Caribbean. Central America had the highest prevalence and the Caribbean the lowest, while South America also had a low prevalence. In contrast, the prevalence of overweight was similar across subregions.

There was an inverse relationship between the prevalence rates of stunting and overweight, but again, with clear differences between subregions. Our analysis indicates that around 10% of the variability in the prevalence of overweight is dependent on the variability of the prevalence of stunting. Overall, these differences in prevalence could be explained by the different relative contributions of key risk factors for underweight and overweight, including socioeconomic status, lifestyle, food accessibility, and physical activity patterns, which themselves are likely to vary greatly across the region.

The results from South America underscore the importance of overweight in this subregion. The prevalence of overweight increased both in the segment of the population with a high prevalence of stunting and in those groups with lower prevalence rates of stunting.

As noted above, differences in social and economic development across countries may account in part for the different relationships between stunting and overweight observed in our study. It is recognized that the interactions between poverty and affluence determining the prevalences of underweight and overweight are complex. The present analysis shows a less strong relationship between GDP and overweight than between GDP and stunting. The contribution of GDP appears to be more limited in South America than in the other subregions.

The observed differences in the coexistence of undernutrition and overnutrition among subregions may be related to their being at different stages in the nutrition transition [18]. Early stages are characterized by food insecurity and high prevalences of underweight and stunting, with little or no obesity. Improved socioeconomic development, along with urbanization, favors excess weight gain in some segments of the population, but with persistent undernutrition, particularly in rural areas. This contrast in obesity prevalence between urban and rural areas has been well documented for several Latin American and Caribbean countries [6]. Finally, in a more advanced stage of socioeconomic transition, the rate of undernutrition will have a downward trend while the rates of overweight and diet-related chronic diseases will continue to increase. Although the Latin American and Caribbean region as a whole is considered to be at a relatively advanced stage of the nutrition transition, our results suggest that there is still a great deal of variability among the subregions.

Stunting has been described as an independent risk factor for the development of obesity. Popkin et al. [19] estimated that the income-adjusted risk ratios of overweight for a stunted child ranged from 1.7 to 7.8 in children aged 3 to 6 and 7 to 9 years, respectively, in nationally representative surveys from Russia, Brazil, South Africa, and China.

The association between nutritional deficiency and overweight has been described in populations experiencing rapid changes in diet and physical activity [20]. Doak et al. [8] compared the coexistence of underweight and overweight in three nationally representative surveys. The authors observed that 23%, 45%, and 58% of households in China, Brazil, and Russia, respectively, that had an underweight member also had an overweight member.

On the basis of the number and characteristics of the studies included in the WHO database, we consider that these results are valid, based on an ecological design, to describe the association between the prevalence of stunting and overweight. The number of data points included in the present analysis (95 from the Caribbean, 100 from Central America, and 270 from South America) represent 6 of the 24 countries in the Caribbean, 7 of the 8 countries in Central America, and 11 of the 14 countries in South America.

From the data analyzed, we conclude that an inverse relationship between stunting and overweight exists, but with differences within the region. Data from South America showed higher prevalence of overweight in subgroups with low or high prevalence of stunting.

Recognition of the association between stunting and overweight, its determinants, and differences among populations is essential for the formulation of nutrient

intake recommendations and for the design of nutrition interventions [21, 22]. The "nutrition paradox" [23], the coexistence of nutritional deficit and excess, underlines the difficulty of designing interventions aimed at reducing undernutrition while addressing at the same time the increasing problem of overweight and obesity.

The phenomenon of nutrition transition in the region and worldwide is highly related to changes in lifestyles associated with the increase in obesity prevalence. Rapid changes in dietary and physical activity patterns can explain the incremental changes in rates of overweight and obesity, progressively shifting towards the poor [24]. But not only higher rates of obesity characterize the process. The complexity of the nutrition transition may lead to the coexistence of nutritional deficits with overweight, even at the household level. This problem must first be recognized in order to design adequate and effective interventions [25]. Rapid changes in economic development and urbanization are relevant factors in this process, and have to be accompanied by adequate food and nutrition policies, promotion of physical activity and healthy habits to reduce undernutrition and simultaneously prevent overweight and obesity.

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Traditional cooked vegetable dishes as important sources of ascorbic acid and β-carotene in the diets of Indian urban and rural families

Shruti Gupta and Kiran Bains

Abstract

Background. *Fresh vegetable produce is abundant during the winter season in Punjab. It is an important source of vitamins and minerals in the Punjabi diet, but the availability of ascorbic acid and β-carotene from the vegetables is altered to varying degrees when they are subjected to traditional household processing methods.*

Objective. *To determine the importance of traditional cooked vegetable dishes as sources of ascorbic acid and β-carotene among urban and rural families during the winter.*

Methods. *Information about vegetable consumption, storage, and cooking practices was collected from 60 families, 30 each from urban and rural areas of Ludhiana District, Punjab, India. Samples of the common cooked vegetable dishes were prepared in the laboratory by methods ascertained from the survey and analyzed for ascorbic acid and β-carotene.*

Results. *The average total daily per capita consumption of vegetables by urban and rural families was 411.7 and 365.9 g, respectively. Cooked vegetable dishes provided 68.7% of the total vegetable intake for urban families and 85.0% for rural families. On average, the edible portion constituted 78.9% of the weight of the vegetables. Ten cooked vegetable dishes that were most frequently consumed by the families (mustard saag, potato–spinach, potato–fenugreek, potato–brinjal, potato–cauliflower, potato–capsicum, potato–carrots, potato–beans, potato–peas, and cabbage–peas) were selected for preparation in the laboratory and nutritional analysis. The average concentrations of ascorbic acid and β-carotene in the cooked vegetable dishes were 46.0 mg/100 g and 794.2 μg/100 g fresh weight, respectively. The percentage losses of ascorbic acid and β-carotene during preparation and cooking were 26.1% and 25.9%, respectively.*

Conclusions. *For adult Indian men and women, the recommended dietary allowance of ascorbic acid is 40 mg, and that of β-carotene is 2,400 μg. Cooked vegetable dishes provided 269.9% and 77.5% of the recommended dietary allowances of ascorbic acid and β-carotene, respectively, indicating that these dishes are good sources of these nutrients in the diets of both urban and rural families during the winter season.*

Key words: Ascorbic acid, β-carotene, cooked vegetable dishes, recommended dietary allowance

Introduction

Green vegetables are among the most valued components of Indian cooking for their color, flavor, therapeutic value, and nutritional value. They are an essential part of the diets of both rich and poor, since the majority of the Indian population is vegetarian. Properly planned and cooked vegetarian diets are healthful and nutritionally adequate and provide health benefits by reducing the risk of several degenerative diseases. Vegetables also make diets esthetically more attractive [1].

Leafy vegetables are valued as a source of vitamins, particularly ascorbic acid and β-carotene. Both of these vitamins have protective effects against damage from free radicals [2]. Variations in the ascorbic acid and β-carotene contents of raw vegetables influence their final content in the cooked vegetables. Water-soluble ascorbic acid is easily lost during washing and cooking [3]. The duration and method of cooking significantly affect ascorbic acid content. Substantial losses of ascorbic acid could be nutritionally important for persons

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consuming large amounts of green vegetables [4]. Ascorbic acid content is readily affected by light, oxygen, heat, enzymes, and metals. β-carotene is also labile and sensitive to heat [5].

Fresh vegetable produce is abundant during the winter season in Punjab. It is an important source of vitamins and minerals in the Punjabi diet, but the availability of ascorbic acid and β-carotene from the vegetables is altered to varying degrees when they are subjected to traditional household processing methods. The present study was therefore planned to study the losses of ascorbic acid and β-carotene during the preparation and cooking of vegetables in the traditional way and to determine the role of the cooked vegetable dishes in providing ascorbic acid and β-carotene in the daily diets of urban and rural families.

Materials and methods

Sixty middle-income families, 30 each from urban and rural areas of Ludhiana District, Punjab, India, were randomly selected. Information regarding the types of traditional cooked vegetable dishes prepared by the families, their frequency of consumption, the ingredients used, and preparation and cooking practices was collected with the use of a pretested questionnaire. The data were collected during the months of November and December when vegetable produce is abundant in Punjab and hence easily available to both urban and rural families. The total consumption of vegetables by the families was assessed by the 24-hour recall method for three consecutive days. Information about the edible portion of common vegetables was obtained by the questionnaire. The percentage of each vegetable that was edible was calculated in the laboratory by weighing both the whole vegetable and the edible portion as reported by the families and dividing the former weight by the latter.

Of 17 popular cooked vegetable dishes, 10 that were consumed frequently (at least once a week) by the majority of the families were selected for chemical analysis. All vegetables used in the preparation of samples were obtained from the local market. The selected vegetable dishes were prepared three times in the Laboratory of the Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, Punjab, following the methods ascertained from the survey regarding ingredients used, preparation, edible portion, and cooking practices. Pressure cooking or cooking in a covered pan were commonly used methods, according to information obtained from the survey; these methods were used in the preparation of samples. The degree of doneness of the vegetables as reported by the majority of selected families was also considered in preparing the samples. The corresponding raw samples of each vegetable dish were also prepared by mixing all the ingredients in the same proportions as in the case of cooked samples to study the effect of cooking on the nutritional quality of the vegetables. The cooked and raw samples were then weighed and homogenized. Ascorbic acid [6] and β-carotene [7] contents were determined as percentages of fresh weight. The moisture content of the samples was analyzed to determine the dry weight of the dishes as there was considerable variation in the moisture content of the dishes. The percent losses in the contents of ascorbic acid and β-carotene during cooking were calculated on a dry weight basis. Ascorbic acid was estimated by the AOVC (Association of Vitamin Chemists) method, and β-carotene by column chromatography. Means and standard deviations were calculated, and differences were tested for significance by Student's *t*-test. For adult Indian men and women, the recommended dietary allowance of ascorbic acid is 40 mg, and that of β-carotene is 2,400 μg [8] The percentage contributions of vegetables to daily ascorbic acid and β-carotene requirements were calculated from survey observations and chemical analysis.

Results and discussion

The daily per capita consumption of vegetables by urban and rural families is shown in **table 1**. The average daily consumption of leafy vegetables in cooked vegetable dishes was 70.0 and 176.0 g in the urban and rural families, respectively. There was a significantly ($p \leq .05$) higher intake of leafy vegetables among rural families, perhaps because of the greater availability of these vegetables in rural areas. The average daily consumption of roots and tubers in cooked vegetable dishes by the urban and rural families was 133.6 and 96.7 g, respectively. The corresponding values for other vegetables, such as cauliflower, capsicum, beans, etc., were 79.3 and 38.4 g. There was a significantly ($p \leq .01$) higher intake of other vegetables by urban families. The average daily per capita consumption of all vegetables in the form of cooked vegetable dishes was 282.9 g in urban families and 311.1 g in rural families. Previous studies in this region also observed a significantly higher intake of vegetables when compared to suggested intakes for Indians, particularly during winter season [9, 10]. Cooked vegetable dishes provided 68.7% of the total daily vegetable consumption for urban families and 85.0% for rural families, followed by salads and cooked non-vegetable dishes based on cereals, legumes, and meat, with small amounts of vegetables, mainly onion, tomato, ginger, and garlic usually used for flavor (**fig. 1**).

The percent edible portion of vegetables is shown in **figure 2**. For leafy vegetables, the percent edible

TABLE 1. Average daily per capita consumption (g) of vegetables by urban and rural families

Type of preparation	Urban (N = 30)		Rural (N = 30)		*p*-value
	Range	Mean ± SD	Range	Mean ± SD	
Cooked vegetable dishes					
Leafy vegetables	6–500	70.0 ± 135.1	4–700	176.0 ± 212.2	≤ .05
Roots and tubers	23–328	133.6 ± 80.6	14–225	96.7 ± 61.2	[NS]
Other vegetables	7–200	79.3 ± 57.7	4–175	38.4 ± 45.4	≤ .01
Total		282.9		311.1	
Other dishes[a]	14–115	47.4 ± 29.8	17–112	20.6 ± 27.1	≤ .01
Salad	22–189	81.4 ± 47.2	18–90	34.2 ± 23.4	≤ .01
Total vegetable intake		411.7		365.9	

NS, not significant

a. Other dishes include cooked dishes based on cereals, legumes, and meat, with small amounts of vegetables, mainly onion, tomato, ginger, and garlic usually used for flavor.

portion ranged from 62.8% to 92.6% for urban families and from 64.7% to 93.0% for rural families, with mean values of 73.4% and 77.2%, respectively. The percent edible portion of roots and tubers ranged from 60.0% to 89.2% for urban families and from 60.0% to 92.8% for rural families, with mean values of 83.9% and 83.3%, respectively. The percent edible portion of other vegetables ranged widely from 30% to 98%, with mean values of 78.1% and 77.4% for urban and rural families,respectively.

The ascorbic acid content of cooked vegetable dishes prepared in the laboratory by the same methods and cooked to the same stage of doneness as reported by the surveyed families ranged from 19.7 to 79.9 mg/100 g, with a mean of 46.0 mg (**table 2**). The maximum ascorbic acid content was found in cabbage–peas, followed by potato–capsicum (69.7 mg). The minimum ascorbic acid content was found in potato–carrots, followed by potato–brinjal (20.2 mg) and potato–peas (20.4 mg). There was a wide variation (from 17.1% to 36.4%) in the losses of ascorbic acid in cooked vegetable dishes. This variation was due to differences in preparation methods, cooking times, and procedures followed for the preparation of individual recipes based on information provided by urban and rural families. The maximum loss of ascorbic acid was found in potato–cauliflower, closely followed by mustard saag (35.9%) and potato–beans (33.3%). The minimum losses occurred in potato–peas (17.1%), owing to the use of a pressure cooker, which reduces ascorbic acid losses by cooking food faster. The average ascorbic acid contents of raw and cooked vegetable dishes were 62.9 and 46.0 mg/100 g, respectively, with an average loss of 26.1% during preparation and cooking. The ascorbic acid loss was 30% to 50% for potatoes cooked in boiling water [11] but only 15% to 25% for potatoes cooked in a pressure cooker. The reported losses of ascorbic acid from fresh green leafy vegetables cooked by various methods were 18.3% for covered-pan cooking, 18.4% for baking, 22.1% for steaming, 33.4% for pressure cooking, and 55.6% for boiling [12].

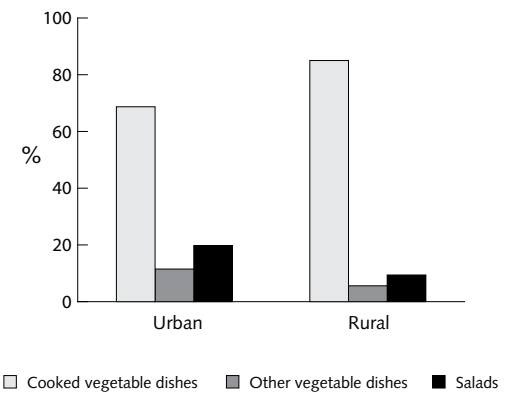

FIG. 1. Percent contribution of cooked vegetable dishes, other dishes, and salads to the total intake of vegetables in urban and rural families ("other dishes" include cooked dishes based on cereals, legumes, and meat, with small amounts of vegetables, mainly onion, tomato, ginger, and garlic usually used for flavor.

The β-carotene content of cooked vegetable dishes ranged from 30.6 µg/100 g for potato–cauliflower

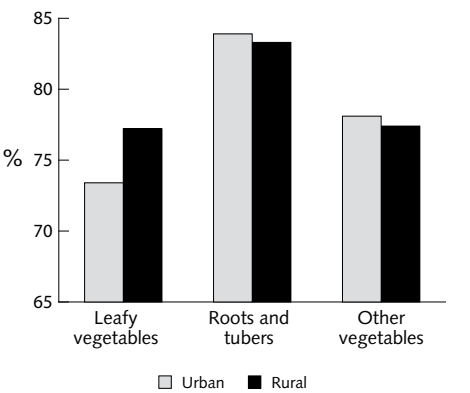

FIG. 2. Percent edible portion of vegetables consumed by urban and rural families

TABLE 2. Ascorbic acid and β-carotene content of raw and cooked vegetable dishes[a]

Vegetable dish	Ascorbic acid (mg)			β-Carotene (μg)		
	Raw	Cooked	% loss	Raw	Cooked	% loss
Mustard saag	75.4	48.3	35.9	3,545.5	2,836.8	19.9
Potato–spinach	55.1	40.2	27.0	2,810.2	2,217.2	21.1
Potato–fenugreek	50.2	39.5	21.3	2,571.3	1,920.5	25.3
Potato–brinjal	24.9	20.2	18.8	202.8	153.7	24.2
Potato–capsicum	99.6	69.7	30.02	503.2	348.3	30.7
Potato–cauliflower	55.4	35.2	36.4	42.7	30.6	28.4
Potato–carrots	25.4	19.7	22.4	1,714.2	1,258.1	26.6
Potato–peas	24.6	20.4	17.1	107.4	75.1	30.1
Potato–beans	44.7	29.8	33.3	58.1	43.5	25.0
Cabbage–peas	100.3	79.9	20.3	197.3	149.3	24.3
Mean ± SD	62.9 ± 31.0	46.0 ± 23.1	26.1 ± 6.9	1,037.8 ± 1,269.8	794.2 ± 999.3	25.9 ± 3.6

a. Values are the average of three replications.

to 2836.8 μg/100 g for mustard saag. The highest β-carotene contents were found in leafy cooked vegetable dishes, which included mustard saag, potato–spinach (2217.2 μg/100 g), and potato–fenugreek (1920.5 μg/100 g). Potato–carrots also had a high β-carotene content (1258.1 μg/100 g). Agarwal et al. [12] reported β-carotene values of 1,764, 1,966, 876, 408, and 19 μg/100 g for spinach, potato–fenugreek, potato–carrots, cabbage–peas, and potato–cauliflower, respectively. The study also found higher β-carotene contents in cooked vegetable dishes that included leafy vegetables or carrots. The percent losses of β-carotene in the cooked vegetable dishes ranged between 19.9% and 30.7%. The maximum loss of β-carotene was in potato–capsicum and the lowest was in mustard saag. Pressure cooking and saucepan cooking resulted in losses of β-carotene ranging from 19.0% to 19.5% and from 28.7% to 30.4%, respectively in various vegetable dishes [13].

Vegetables are both the greatest contributor and most plentiful source of vitamins in the daily diet. The total consumption of vegetables depends on seasonal availability and individual preferences. Seasonal vegetables are quite cheap in India because of a lack of adequate infrastructure for post-harvest processing. Vegetables are usually cooked before they are eaten. The results showed that the contribution of cooked vegetable dishes to total vegetable intake was 68.7% and 85.0% in urban and rural families, respectively, during the winter season. The vegetable consumption of both urban and rural families was higher than the RDAs of the Indian Council of Medical Research [8]. The total per capita vegetable intake in the form of cooked vegetable dishes was 282.9 g and 311.1 g in urban and rural families, respectively. The consumption of vegetables observed in this study was high because the study was conducted during the winter when vegetables are readily available in Punjab. There was a wide variation among vegetables in the percent edible portion. The average percent edible portions for urban and rural families were 73.4% and 77.2% for leafy vegetables, 83.9% and 83.3% for roots and tubers, and 78.1% and 77.4% for other vegetables, respectively. The average percent edible portion for all vegetables was 78.5% for urban families and 79.3% for rural families. The daily per capita consumption of the vegetables (edible portion) used in common cooked vegetable dishes was 222.1 g for urban families and 246.7 g for rural families. The average losses of ascorbic acid and β-carotene during preparation and cooking of vegetable dishes were 26.1% and 25.9%, respectively. The RDAs of ascorbic acid and β-carotene for Indian adult men and women are 40 mg and 2,400 μg, respectively [8]. Cooked vegetable dishes provided 102.2 mg of ascorbic acid and 1763.9 μg of β-carotene daily in urban families and 113.7 mg of ascorbic acid and 1959.3 μg of β-carotene in rural families. In urban families, vegetable dishes provided 255.5% of the RDA for ascorbic acid and 73.5% of the RDA for β-carotene. The corresponding percentages for rural families were 284.3% and 81.6% (**fig. 3**). The average values for both urban and rural families were 269.9% and 77.5 of the recommended dietary allowances of ascorbic acid and β-carotene, respectively.

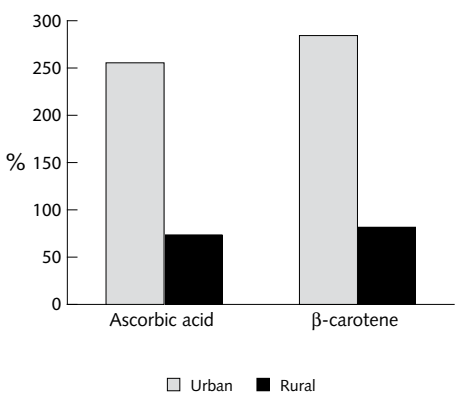

FIG. 3. Percentage of recommended dietary allowance (RDA) of ascorbic acid and β-carotene provided by cooked vegetable dishes in urban and rural families

Conclusions

The selected urban and rural Punjabi families consumed most of their vegetables in the form of traditional cooked dishes. The average percent edible portion for all vegetables in these dishes was 78.9%. The percent losses of ascorbic acid and β-carotene were 26.1% and 25.9%, respectively, during preparation and cooking. Despite these losses, the cooked vegetable dishes were important sources of vitamins during the winter, when vegetables are available in abundance. Therefore, the use of traditional cooked vegetable dishes in the daily diet should be encouraged to obtain maximum nutritional benefits from the vegetables. The cooked vegetable dishes provide appreciable amounts of antioxidant vitamins and thus may prove helpful in preventing nutritional deficiencies and the risk of degenerative diseases.

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Prevalence of anemia among pregnant women and adolescent girls in 16 districts of India

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Abstract

Background. *Nutritional anemia is one of India's major public health problems. The prevalence of anemia ranges from 33% to 89% among pregnant women and is more than 60% among adolescent girls. Under the anemia prevention and control program of the Government of India, iron and folic acid tablets are distributed to pregnant women, but no such program exists for adolescent girls.*

Objective. *To assess the status of anemia among pregnant women and adolescent girls from 16 districts of 11 states of India.*

Methods. *A two-stage random sampling method was used to select 30 clusters on the basis of probability proportional to size. Anemia was diagnosed by estimating the hemoglobin concentration in the blood with the use of the indirect cyanmethemoglobin method.*

Results. *The survey data showed that 84.9% of pregnant women (*n = *6,923) were anemic (hemoglobin < 110 g/L); 13.1% had severe anemia (hemoglobin < 70 g/L), and 60.1% had moderate anemia (hemoglobin ≥ 70 to 100 g/L). Among adolescent girls (*n = *4,337) from 16 districts, the overall prevalence of anemia (defined as hemoglobin < 120 g/L) was 90.1%, with 7.1% having severe anemia (hemoglobin < 70 g/L).*

Conclusions. *Any intervention strategy for this population must address not only the problem of iron deficiency, but also deficiencies of other micronutrients, such as B12 and folic acid and other possible causal factors.*

Key words: Adolescent girls, anemia, pregnant women, prevalence

Introduction

Anemia in pregnant women and adolescent girls has serious health implications. Severe anemia during pregnancy significantly contributes to maternal mortality and morbidity [1, 2]. There is evidence that severe anemia also increases perinatal morbidity and mortality by causing intrauterine growth retardation and preterm delivery [3]. Anemia in adolescent girls affects their physical work capacity and reproductive physiology [4]. According to a World Health Organization (WHO) report [5], the global prevalence of anemia among pregnant women is 55.9%. In India, the prevalence of anemia in pregnant women has been reported to be in the range of 33% to 89% [6–12]. According to the limited number of studies from India, the prevalence of anemia in adolescent girls is also fairly high [13, 14]. Anemia results both from nutrition-related causes and from inflammatory or infectious diseases, as well as from blood loss. Iron-deficiency anemia resulting from inadequate intake and low absorption of dietary iron is the most common form of anemia in India [15, 16]. India launched the National Nutritional Anaemia Prophylaxis Programme (NNAPP) in 1970. Under the program, iron and folic acid tablets are distributed to pregnant women. However, no impact of this program

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on the prevalence of anemia was observed in an evaluation conducted during 1985–86 [8]. Consequently, certain modifications were made in the NNAPP to make it more effective and efficient [14]. The present paper reports the prevalence of anemia among pregnant women and adolescent girls in 16 districts from 11 states of India.

Methods

Sixteen districts were selected for the study: eight from the northern, six from the eastern and northeastern, and one each from the southern and western regions of India. The survey was conducted by two-stage random sampling, and 30 clusters were selected on the basis of probability proportional to size, with operational feasibility kept in view and on the assumptions of an expected prevalence of 70% among pregnant women, a confidence level of 95%, a relative margin of error of 10%, and a design effect of 3 [17]. A total of 495 pregnant women per district (17 per cluster) were selected at random. Assessment of anemia in unmarried adolescent girls (11 to 18 years old) was carried out with a sample size of 10 girls per cluster. Informed consent was obtained in writing from the subjects prior to the collection of blood samples after explaining the purpose of the study.* The hemoglobin concentration in the blood of the pregnant women and adolescent girls was estimated by the indirect cyanmethemoglobin method [18, 19]. Hemoglobin concentrations were not adjusted for altitude, since only two high-altitude locations were sampled in the study.

Blood (in 20-µl samples) was transferred to Whatman filter paper no. 1 and dried at room temperature. After the blood had dried, the filter paper was placed in an envelope and transported to the laboratory. The portion of the filter paper with blood was placed in 5 ml of Drabkin's solution and vortexed for 5 minutes. The solution was allowed to stand for 2 hours, and the hemoglobin concentration was measured at a wavelength of 540 nm by a spectrophotometer. The estimates were performed within 6 days of sample collection. Blood samples collected on Whatman filter paper by this method have been reported to be completely eluted, and the hemoglobin concentration values simultaneously estimated by the direct and indirect cyanmethemoglobin methods were in close agreement [19].

Anemia was assessed according to WHO criteria [20]. A hemoglobin concentration of less than 110 g/L in a pregnant woman or less than 120 g/L in an adolescent girl was considered an indication of anemia. In the case of pregnant women, hemoglobin concentrations of less than 70, 70 to 100, and 100 to 109 g/L were considered to indicate severe, moderate, and mild anemia, respectively. In the case of adolescent girls, hemoglobin concentrations of less than 70, 70 to 100, and 100 to 119 g/L were considered to indicate severe, moderate, and mild anemia, respectively.

*This multicenter study was approved by the Project Review Group of the Indian Council of Medical Research (ICMR).

Results

Prevalence of anemia in pregnant women

The measurements of hemoglobin concentration indicated that the prevalence of anemia among the 6,923 pregnant women from the 16 districts was 84.9%. The prevalence within districts ranged from 61.0% in Mandi District to 96.8% in Srinagar District (**table 1**). The average prevalence of anemia was 83.0% in the eight districts from northern India and 86.8% in the six districts from eastern India. The prevalence rates in the single districts from southern India (Mehboob Nagar) and western India (Raigarh) were 92.1% and 87.2%, respectively.

The average prevalence of severe anemia was 13.1%; the highest prevalence (38.2%) was in Bikaner District and the lowest (zero) was in Kohima District. The prevalence of severe anemia was 13.5% in the eight districts from northern India, 12.1% in the six districts from eastern India, 12.7% in the single district from southern India, and 14.8% in the single district from western India.

The overall prevalence of moderate and mild anemia in pregnant women was 60.1% and 11.8%, respectively. The highest prevalence of moderate anemia was found in Nagaon District (82.7%) and the highest prevalence of mild anemia (31.0%) in Mandi District (**table 1**). The lowest prevalence rates of moderate (28.0%) and mild (4.7%) anemia were recorded in pregnant women of Mandi and Gaya Districts, respectively.

Prevalence of anemia in adolescent girls

Table 2 presents the hemoglobin concentrations of the 4,337 unmarried adolescent girls from the 16 districts. The results indicate that 90.1% of the girls were anemic. The prevalence of anemia ranged from 58.2% in Dehradun District to 100% in Badaun District. The average prevalence of anemia was 89.4% in the eight districts from northern India, 91.4% in the six districts from eastern India, and 91.8% and 87.0% in the single districts from southern India (Mehboob Nagar) and western India (Raigarh), respectively.

The overall prevalence of severe anemia was 7.1%, with the highest prevalence (24.3%) in Bikaner District. No severely anemic girls were found in Bishnupur and Kohima Districts. The average prevalence of severe

TABLE 1. Prevalence of anemia among pregnant women

District	No. of women	No. (%) with anemia			
		Total (Hb < 110 g/L)	Mild (Hb 100–109 g/L)	Moderate (Hb 70–100 g/L)	Severe (Hb < 70 g/L)
North					
Mandi	507	309 (61.0)	157 (31.0)	142 (28.0)	10 (2.0)
Dehradun	340	220 (64.7)	43 (12.6)	158 (46.5)	19 (5.6)
Lakhimpur Kheri	593	471 (79.4)	88 (14.8)	325 (54.8)	58 (9.8)
Badaun	488	395 (80.9)	96 (19.7)	283 (58.0)	16 (3.3)
Baramullah	504	460 (91.3)	46 (9.1)	342 (67.9)	72 (14.3)
Bikaner	510	484 (94.9)	34 (6.7)	255 (50.0)	195 (38.2)
Mainpuri	253	243 (96.0)	18 (7.1)	182 (71.9)	43 (17.0)
Srinagar	498	482 (96.8)	26 (5.2)	370 (74.3)	86 (17.3)
East					
Kohima	69	47 (68.1)	10 (14.5)	37 (53.6)	0
Bishnupur	508	391 (77.0)	76 (15.0)	313 (61.6)	2 (0.4)
Gaya	446	375 (84.1)	21 (4.7)	267 (59.9)	87 (19.5)
Patna	512	462 (90.2)	28 (5.5)	298 (58.2)	136 (26.6)
Dibrugarh	525	480 (91.4)	52 (9.9)	371 (70.7)	57 (10.8)
Nagaon	475	446 (93.9)	29 (6.1)	393 (82.7)	24 (5.1)
South					
Mehboob Nagar	189	174 (92.1)	14 (7.4)	136 (72.0)	24 (12.7)
West					
Raigarh	506	441 (87.2)	79 (15.6)	287 (56.7)	75 (14.8)
All districts	6,923	5,880 (84.9)	817 (11.8)	4,159 (60.1)	904 (13.1)

Hb, hemoglobin

anemia was 7.4% in the eight northern districts, 5.7% in the six eastern districts, 9.2% in the single southern district, and 11.1% in the single western district.

The overall prevalence rates of moderate and mild anemia were 50.9% and 32.1%, respectively. Patna District had the highest prevalence of moderate anemia (72.2%), and Mandi District had the highest prevalence of mild anemia (57.9%) (**table 2**). Dehradun District had the lowest prevalence of moderate anemia (27.7%), and Gaya District had the lowest prevalence of mild anemia (14.4%).

Discussion

The average prevalence of anemia among pregnant women from 16 districts of 11 states of India during the present survey was 84.9%. A previous multicenter study carried out during 1985–86 in 11 states found an overall prevalence of anemia of 87.5% among pregnant women [8]. These prevalence values are essentially the same as those reported in earlier studies carried out in India during the 1940s, 1950s, and 1960s [21, 22]. However, the National Family Health Survey 2 (NFHS-2) conducted during 1998–99 found an overall prevalence of 49.7% among 5,654 pregnant women from 25 states [23]. The lower prevalence observed during the NFHS-2 survey could be due to the use of the HemoCue method, which gives higher estimates of hemoglobin concentration than the standard method [24, 25].

Sari et al. [26], however, reported that the prevalence of anemia was significantly higher when hemoglobin concentrations were estimated by the indirect cyanmethemoglobin method than when they were estimated by the direct cyanmethemoglobin and HemoCue methods. Sari and coworkers suggested that the higher estimates obtained by the indirect method may have been due to incomplete dissolution of blood from the filter paper into Drabkin's solution. Comparison of findings of the prevalence of anemia obtained by different methods of hemoglobin estimation, therefore, may not be strictly valid without critical evaluation of methodologic differences. Although the complete dissolution of blood from filter paper into Drabkin's solution was ensured in the present study, the results obtained through the use of indirect methods may not be strictly comparable to results reported from other studies that used the direct cyanmethemoglobin method.

Thus, anemia remains endemic among pregnant women in India despite intervention measures such as the distribution of 100 Folifer tablets (containing 100 mg of elemental iron and 500 μg of folic acid) to each

TABLE 2. Prevalence of anemia among adolescent girls

District	No. of girls	No. (%) with anemia			
		Total (Hb < 120 g/L)	Mild (Hb 100–119 g/L)	Moderate (Hb 70–100 g/L)	Severe (Hb < 70 g/L)
North					
Dehradun	213	124 (58.2)	62 (29.1)	59 (27.7)	3 (1.4)
Baramullah	300	259 (86.3)	101 (33.7)	153 (51.0)	5 (1.7)
Mandi	285	250 (87.7)	165 (57.9)	83 (29.1)	2 (0.7)
Bikaner	300	271 (90.3)	56 (18.7)	142 (47.3)	73 (24.3)
Lakhimpur Kheri	294	271 (92.2)	97 (33.0)	148 (50.3)	26 (8.8)
Mainpuri	147	140 (95.2)	43 (29.3)	92 (62.6)	5 (3.4)
Srinagar	296	294 (99.3)	80 (27.0)	199 (67.2)	15 (5.1)
Badaun	299	299 (100.0)	121 (40.5)	150 (50.2)	28 (9.4)
East					
Bishnupur	300	238 (79.3)	123 (41.0)	115 (38.3)	0
Kohima	99	88 (88.9)	39 (39.4)	49 (49.5)	0
Gaya	285	262 (91.9)	41 (14.4)	178 (62.4)	43 (15.1)
Dibrugarh	296	278 (93.9)	105 (35.5)	147 (49.7)	26 (8.8)
Nagaon	297	281 (94.6)	97 (32.7)	178 (59.9)	6 (2.0)
Patna	317	310 (97.8)	65 (20.5)	229 (72.2)	16 (5.1)
South					
Mehboob Nagar	294	270 (91.8)	105 (35.7)	138 (46.9)	27 (9.2)
West					
Raigarh	315	274 (87.0)	92 (29.2)	147 (46.7)	35 (11.1)
All districts	4,337	3,909 (90.1)	1,392 (32.1)	2,207 (50.9)	310 (7.1)

Hb, hemoglobin

woman to be taken during pregnancy.

Some of the reasons that iron supplementation programs are ineffective may be that the programs do not always reach the target people, health staff are inadequately trained and mobilized to ensure the effective distribution of supplements, and compliance is low, due, in particular, to the side effects associated with iron supplements [8, 27]. Stoltzfus [27] considered that a more fundamental reason why strategies to tackle anemia have difficulty in succeeding is that they too often confine themselves solely to the correction of iron deficiency. It is unlikely that all anemia results from iron deficiency, because other nutritional deficiencies, as well as malaria, heavy loads of some helminths, and other inflammatory or infectious diseases, also cause anemia. A successful strategy to combat anemia, therefore, should address all of the causal factors after their elucidation.

The overall prevalence of severe anemia (hemoglobin < 70 g/L) among pregnant women was 13.1%, ranging up to 38.2% in Bikaner District. A prevalence of 8.3% for severe anemia has been reported among lactating and pregnant women in the slums of Hyderabad [28]. However, the prevalence of severe anemia among pregnant women was as high as 56% in a population-based survey (1990–94) of rural and urban areas in Punjab. In the NFHS-2 study, the overall prevalence of severe anemia was only 2.5%. As stated above, such a low prevalence could be due to the use of the HemoCue method, which overestimates the level of hemoglobin.

The overall prevalence of anemia among adolescent girls was 90.1%; the prevalence rates of mild, moderate, and severe anemia were 32.1%, 50.9%, and 7.1% respectively. In a study of 1,500 rural girls 10 to 19 years of age from 10 villages in Gujarat, the prevalence of anemia (hemoglobin < 120 g/L) was reported to be 60% [4]. A recent study conducted in rural, tribal, and urban areas in Vadodara District of Gujarat found a 74.7% prevalence of anemia. After weekly supplementation with iron–folic acid tablets, the prevalence was reduced by 20.5%, with a mean rise in hemoglobin level of 6.9 g/L, a result suggesting that iron deficiency was the predominant causal factor of anemia [29]. The anemia prevalence among adolescent girls in Delhi was 46.6% for those in the high socioeconomic group and 56% for those in the lower-middle socioeconomic group [30]. An 11-country study found that more than 40% of adolescents in Asian countries, including India, were anemic (hemoglobin < 115 g/L) [31]. A review of Indian studies by Kanani and Ghanekar [13] found that more than 70% of adolescent girls from low-income families had hemoglobin levels of less than 110 g/L. When the WHO cutoff value of 120 g/L was applied,

the prevalence was even higher (80% to 90%). The poor nutritional status of adolescent girls has important implications for physical work capacity and adverse reproductive outcome. The median age of marriage in India is around 18 years. When a woman enters pregnancy with a large iron deficit and is subjected to the added demands for iron during pregnancy, it may be too late to address the problem of anemia during pregnancy. We therefore suggest that the health-care system should not miss the opportunities afforded during the precious years of adolescence before marriage and childbearing. Adolescent girls should be supplied with iron–folic acid supplements so that they enter pregnancy with no serious iron-deficiency handicaps.

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Characteristics attributed to complementary foods by caregivers in four countries of Latin America and the Caribbean

Tanushree Dutta, Sara M. Sywulka, Edward A. Frongillo, and Chessa K. Lutter

Commentary

The following paper by Dutta and colleagues is a large, multicountry study funded by the Pan American Health Organization (PAHO). The study seeks to provide a cultural basis for improving early childhood nutrition in Latin America and the Caribbean by encouraging introduction of nutritious and safe complementary foods along with breastfeeding. Although it showcases the latest concepts and procedures in nutrition research (all the references are from 1993 or later), this paper unintentionally demonstrates their methodological failings.

The marketing approach, based on the elicitation and analysis of attributes of specific foods, is inappropriate to the problem for several reasons. To begin with, we already know, based on years of "weaning-food" and "infant-feeding" research, that mothers or surrogates feed children paps and other items for several reasons. First, these foods are accessible, since they are affordable relative to other foods (eggs are economical) and may be the common foods the adults are already eating. Second, the foods are perceived to be nutritious (a category that by the 1980s was becoming multidimensional and showed that mothers were syncretizing "vitamin" and "nutritious" categories to traditional folk categories such as "hot-cold" or "heavy") and nonharmful. Finally, the foods are tasty, filling, and acceptable to the child. The current study does not really add to this nutrition knowledge, but neither does it contradict it.

In addition, common sense, as well as earlier research, emphasizes that it is not just the identities of the particular foods, but the ways in which they are prepared, that make them good or bad for children's nutrition. The "beans" mentioned in the article are a case in point. Are they fed whole? Mashed? As bean soup? There is an important nutrition literature just on beans relevant to infant feeding, which suggests that the authors should have probed the "many negative attributes" caregivers associated with beans and their preparations. Any nutrition education program must consider not just the foods, but also their manner of preparation, and whether caregivers take time and resources to prepare special foods for children. The larger question is which foods are specially prepared and purchased for infants—and why.

What is interesting to note in the results of the paper is the finding that people are picking up bits and pieces of popular nutrition knowledge from the media or other sources, including the idea that chicken may have "too much fat" and be "artificial," as well as the suggestion that all these foods have protein, vitamins, and minerals. But what does this actually tell the nutrition educator?

In the reporting of results, only the final tables summarizing attributes of ordinary and manufactured foods are useful. The others are literally putting beans and oranges in the same class, and this is not helpful. However, manufacturers might be interested in the positive and negative attributes associated with their foods.

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Abstract

Background. *Attributes that caregivers assign to complementary foods have been primarily described in the*

context of illness, but attributes assigned to foods in everyday circumstances must be understood to effectively promote good complementary feeding.

Objective. *This study aimed to understand how mothers judge complementary foods to be appropriate by cross-cultural examination of food perceptions in four different Latin American and Caribbean countries.*

Methods. *We used semistructured interviews to assess attributes that mothers ascribed to a list of key foods, both home-made and manufactured, and reasons for feeding or not feeding them. We elicited attributes from 79 caregivers with children 6 to 24 months of age from two urban and periurban sites each in Brazil, Jamaica, Mexico, and Panama.*

Results. *Textual analysis based on six home foods common to the four countries and manufactured foods resulted in six attribute categories, five of which could be positive or negative (Nutrient Content, Effects on Child, Child's Response, Availability and Accessibility, and Other Food Attributes); one (Food Quality and Safety) was only negative. Analysis of attributes of home foods (chicken, eggs, beans, carrots, bananas or plantains, and oranges) revealed many beliefs that were common within and across countries, whereas analysis of the attributes of manufactured foods revealed that these foods were less known.*

Conclusions. *The consistency of the attribute categories across countries and across home and manufactured foods suggests their relevance to planning programs to improve complementary feeding in Latin America and the Caribbean and possibly other developing countries. These results can be used programmatically to assess the need for and the focus of food education programs, and to indicate which countries will be more receptive to certain foods as a means of improving complementary feeding.*

Key words: Complementary feeding, food attributes, infants, program planning

Introduction

The first two years of a child's life are a critical period. Following about six months of exclusive breastfeeding, after which breastmilk alone does not provide adequate nutrition for the growing child, complementary foods must be introduced. Providing better complementary feeding should improve the nutritional status of children around the world. Often, however, the complementary foods that are fed to children lack sufficient macro- and micronutrients [1]. Furthermore, infants and young children are often not fed complementary food in an optimal manner. To improve complementary feeding, we need to understand the attributes that caregivers ascribe to foods in their specific cultural setting. Without this understanding, the accessible and nutritious foods that health and nutritional professionals recommend will not be the ones that caregivers give to their infants. Currently, as reviewed below, the attributes caregivers assign to complementary foods are described in the literature primarily in the context of illness, but the attributes assigned to complementary foods in everyday circumstances must be understood to effectively promote good complementary feeding.

Complementary foods can be categorized as home foods, fortified foods, or industrially manufactured foods. Home foods are less expensive, readily available, and culturally acceptable. However, such foods often do not have the nutrient density needed by infants and young children to satisfy their requirements [2] unless animal-source foods are included [3]. Fortification of staple foods, while benefiting the population at large, may not benefit infants and young children because they do not eat enough staple foods for fortification to have an impact. A third option is industrially manufactured complementary foods that are specifically produced for infants. Although these have the potential to improve nutrient intake, their unfamiliarity, lack of availability, and possible high cost could discourage their use as complementary foods.

Regardless of the degree of processing, complementary foods should have specific attributes that encourage their use in infant feeding. Nutritional scientists consider the innate biological properties of foods as valuable; specifically, complementary foods should be sufficiently energy- and micronutrient-dense and should be safe for infant consumption. They should also taste good and be easy to prepare and feed. Energy- and micronutrient-dense foods should also be accessible, both monetarily and physically, to caregivers. Improving the availability and accessibility of low-cost nutritious complementary foods could be an incentive for caregivers to make healthy choices [1].

Nutrient density and accessibility, although they are necessary, are not sufficient; the caregiver has to think of the food as an appropriate complementary food. Whereas nutritional scientists consider the inherent biological properties of foods, caregivers have their own understanding of the properties of foods based on their own culture. To caregivers, then, these foods have inherent *attributes* that may or may not make them appealing complementary foods. Culturally speaking, some infant foods have taboos against them, whereas others are considered essential in infant feeding. Attributes of a food may be illustrative of a belief system about the effects of the food, including how safe the food is, the nutrient content of the food, and inherent content of the food that causes illness [4]. Attributes may also include the palatability of the food, its aesthetics, its cost, ease of access to the food, and whether how it is prepared is acceptable [5].

Attributes can be inferred indirectly from the literature on complementary feeding, which mentions them in connection with illness, feeding practice, or the caregiver's environmental circumstances. These attributes are specific to the local community. Sellen's study of decision-making in a rural east African population found that semisolid foods were eliminated from infants' diets when they were suffering from diarrhea [6]. Similarly, Harrison et al. found that mothers avoided giving their children certain foods and spices when the children were ill [7]. Martinez et al. found that mothers used certain foods to cure or treat childhood diarrhea [8]. Kruger and Gericke noted that mothers in one location believed that *samp*, a type of corn porridge, would prevent illness in infants [9]. Kruger and Gericke's study, conducted in the Moretele District of South Africa, tried to assess mothers' knowledge of the appropriateness of foods as complementary foods. The study reported mothers' specific beliefs regarding certain foods, such as "pumpkin helps to build bones," and concluded that their knowledge of foods was deficient, but it did not provide a framework of what characteristics mothers might use to think about foods.

Foods are often classified into hot-cold or heavy-light categories. The classifications vary between regions and reveal beliefs about how the child's gastrointestinal tract is affected by food. In Cairo, Egypt, mothers avoid giving sick children such foods as onions, tomatoes, fish, eggs, and certain spices because they are too "heavy" [7]. In Guatemala, mothers avoid giving meat and whole beans to children who do not yet have teeth or who are ill because these are also considered "heavy" [10]. In Mexico, mothers prefer to give children "cold" foods, especially when they are ill; fish, cactus, fresh fruits, and raw vegetables are considered cold foods, whereas breastmilk, chocolate, meat, grains, and chilies are considered hot [11]. In Haryana, India, curd (the coagulated product of milk when it sours or is treated with enzymes) is considered cold [12]. In Bangladesh, "hot" foods such as beef, eggs, fish, sweet potato, jackfruit, and most lentils, were not given to young children because they were thought to cause upset stomach [13].

One of the more comprehensive studies of mothers' beliefs of foods was conducted by Hayes et al. in Lusaka, Zambia [14]. The purpose of the study was to provide background information for the development of a weaning blend formula. Questionnaires assessed food preferences and aversions, frequencies of mothers' inclination to use each of 55 different foods, and feeding during illness. The study found that the three most frequent reasons for preferring a food were "health and growth," "better growth," and "the child liked a particular food."

Previous research on complementary feeding has mentioned beliefs about the attributes of appropriate complementary foods only incidentally as part of a discussion of illness, and has not tried to explain the attributes of foods that affect mothers' decisions whether to feed them to their children. Our study, in contrast, focused directly on the attributes of food to understand how mothers judge key foods to be appropriate as complementary foods. The study examined cross-cultural perceptions about food in four Latin American or Caribbean countries: Brazil, Jamaica, Mexico, and Panama. Semistructured interviews were used to assess the positive and negative attributes that mothers ascribed to a list of key foods, both home and manufactured, as well as their reasons for feeding or not feeding those foods.

Methods

The study was part of a large multicenter study conducted by the Pan American Health Organization (PAHO) in Brazil, Jamaica, Mexico, and Panama. The goals of the large study were to forge a strategy for the prevention of early childhood malnutrition by improving complementary feeding practices, improving access to fortified complementary foods, documenting access to the commercial food market and demand for processed foods, and documenting the availability and prices of complementary foods on the commercial market. The study reported in this paper aimed to contribute to the first of these four goals. The study was reviewed and approved by the Cornell University committee on human subjects. Written informed consent was obtained from each literate study participant, or oral consent was recorded by the fieldworker if a participant was not literate.

The results of the survey and interviews were analyzed with a common protocol by each country by the Process for the Promotion of Child Feeding (ProPAN) method [15]. The aims were to identify the positive and negative characteristics attributed to key foods by the participants; determine which key foods were given and not given to children and why; determine the ages at which children were offered the foods for the first time, how they were prepared for children of that age, and how they are prepared for children at their current age, and to explore the changes that would be necessary to persuade mothers to offer foods to children under 2 years of age that are not currently offered to children of this age.

Two supervisors and four fieldworkers in each of the four countries sampled two poor urban or periurban sites for a total of eight sites: Pelotas and Pinheiro Machado in Brazil, St. Catherine and Kingston in Jamaica, Jojutla and Mexico City in Mexico, and Chilibre and Chepo in Panama. The intention was to choose sites where the population was predominantly poor but not among the very poorest segments. Each country determined the criteria of poverty used for the selec-

tion of sites differently by measures that included the percentage of the site's population earning less than the national minimum wage, the lowest income quartile, and other socioeconomic factors. Logistic factors, such as the presence of roads and health clinics, were also considered in the selection of the sites.

Each country developed a list of 25 to 30 key complementary foods that included frequently consumed foods (as assessed by a 24-hour recall survey), nutrient-rich foods, and fat-rich foods. These foods were also chosen on the basis of their availability (as assessed by a market survey and nutritionist's knowledge) and low cost. The countries developed picture booklets with images of the various foods that they then used to conduct semistructured interviews with the caregivers. Before they were used in the semistructured interviews, the picture booklets were validated by fieldworkers who asked 10 caregivers in the community to identify each food in the picture.

The semistructured interviews were conducted individually with 8 to 12 caregivers of children aged 6 to 24 months at each of the eight sites, for a total of 79 caregivers. The number of caregivers interviewed per country was based on previous experience with the ProPAN method that found that this number was sufficient to uncover attributes of the key foods [15]. The caregivers were chosen randomly in Brazil and Mexico and purposively in Jamaica and Panama. For example, in Jamaica the caregivers were chosen by the fieldworkers according to four main criteria: the caregiver had to live at the study site and have a child 6 to 24 months of age at the time of recruitment, be at or near the home during recruitment, be willing to cooperate, and be available and willing to travel to participate in a recipe-creation exercise. In Brazil, on the other hand, the caregivers were randomly selected from among the 80 caregivers in the first 24-hour recall survey that had been conducted previously. Replacement caregivers were also randomly selected in case the first 10 in each site could not be contacted after at least 2 visits. The interviews were conducted over a period of 6 weeks.

During the interviews, it was first explained to the caregiver that there were no correct or incorrect answers, and that the information she provided was important for understanding the feeding practices of children under 24 months of age so that other caregivers could be helped. The first card was then shown, and the caregiver was asked whether she fed the particular food to the child. The primary goal of the interview was to identify the positive and negative characteristics of the key foods. The interview guide outlined a series of questions, but the interviewer was directed to ask supplementary questions to obtain a complete understanding of the food attributes.

For each key food, the interviewer asked the caregiver whether she fed it to her child and her reasons for feeding or not feeding it. The interviewer also asked the caregiver what else she knew about the food and what other mothers in the community said about the food. These questions were used to prompt the caregivers to reveal their beliefs regarding the attributes of foods.

For each key food that the caregiver gave her child, the caregiver was also asked how old the child was when he or she first received the food or at what age she would give a child the food, how she prepared the food and fed it to her child, and how often she gave the food to the child. If the caregiver did not or would not give the food to the child, she was asked how it could be prepared so that the child would eat it. The interviews were tape-recorded and transcribed or detailed notes were taken. These notes were then transferred to a matrix that first recorded the positive attributes, then the negative attributes, and finally the rest of the collected information for each key food.

The cross-country analysis focused on six home foods that were common to all country key foods lists as well as all of the manufactured foods on the key foods list that were specific to infant feeding. The six home foods (eggs, beans, chicken, carrots, bananas or plantains, and oranges) were chosen because of their nutritional diversity. There were seven manufactured foods, each of which was available in one to three of the countries: Nestum cereal (Jamaica, Mexico, and Panama), Gerber fruit (Mexico and Panama), Gerber vegetables and meat (Mexico and Panama), Gerber cereal (Mexico), Danonino (Mexico), Nutricrema (Panama), and Cerevita (Panama).

The principal analyst among the authors worked in conjunction with three other analysts to review the interviews obtained in each of the four countries. The original interview transcripts were collected from each country, and each transcript was read by the principal analyst and at least one other analyst to discuss and diagram themes that emerged. Electronically available interviews were coded by Atlas Ti. Each set of analyses was discussed by at least two analysts to ensure consistency, and peer debriefing occurred periodically with the larger group. After the analysis for a country was complete, the results were sent back to the investigators in the country to make certain that the portrayal of the information was accurate. The investigators in the four countries were involved throughout the analysis in answering questions or providing clarifications.

Data from the semistructured interviews were first considered site by site and then were aggregated by country. Tabular displays were used to organize information from the semistructured interviews [16]. These displays showed the number of children at a particular age who were and were not introduced to each of the foods from the key foods list. The positive attributes of the foods were tabulated across the eight sites according to eight categories: Nutrient Content, Effects on Child, Child's Response, Other Food Attributes, Reasons for Feeding, Availability and Accessibility, Awareness of

Availability of the Food, and Other. The difference between "Other Food Attributes" and "Other" arises from whether the attribute was specific to the food or referred to the environment or circumstances. For example, the former category was used to tabulate "It has a bad odor" or "It has hormones," whereas the latter category was used to tabulate "The family doesn't eat it" or "The ones they sell in the store aren't fresh."

The negative attributes were also tabulated across the eight sites, and were categorized under Nutrient Content, Effects on Child, Child's Response, Availability and Accessibility, Food Quality and Safety, and Other Food Attributes. The frequency with which foods were fed, the age groups of the children, and the number of mothers who prepared the food in each of the different ways were tabulated. The frequencies of each of the attributes of both home and manufactured foods were considered both within a country and across countries.

Results

Analysis of interview transcripts revealed food attribute categories that caregivers used to think about foods, specifically which foods are appropriate as complementary foods. These attribute categories were common across the eight sites in the four countries, and they often were common across home and manufactured foods. These common ways of thinking about foods were Nutrient Content, Effects on Child, Child's Response, Reasons for Feeding, Availability and Accessibility, Awareness of Availability of the Food, and Other Food Attributes that did not relate directly to the

TABLE 1. Positive attribute categories and examples of attributes of home foods

Attribute category	Description	Examples of attribute
Nutrient content	Caregiver describes food as having specific nutrients (protein, carbohydrates, fat, micronutrients, minerals, calories, water)	The yolk has vitamins It has calcium It has protein It has substances that are necessary for the body It has iron It has phosphorus
Effects on child	Something about the food helps the child grow healthy or does not affect the child's growth negatively	It helps with bones It's easy to digest It's complete The vitamins help the child grow fast It prevents or cures anemia The baby needs white meat Chicken is the best meat to give babies Beef elevates the level of red blood cells It's better for babies than bag juice (i.e., boxed juice) It builds nerves It helps the child's mind to be more awake It helps children to recognize tastes of fruits It's not harmful
Child's response	Whether the child likes the food; characteristics of the food the child likes	The child likes it The child likes it green and ripe It's the only meat the child eats or likes
Availability and accessibility	Available relatively nearby; seasonally available; affordable prices	It's cheap It's easy to get It's always available The mother buys it when the price is reasonable
Other food attributes	Given by caregiver, not necessarily related to effect on child	It has to be free-ranging You can plant it It's filling It's natural It's equivalent to chicken It's tasty It's better than beef It flavors the food It varies the food It's natural; it has no chemicals; it's more natural than beef It's a vegetable It's a good snack between meals

child. The negative attributes of home foods included the above as well as the Quality and Safety of the complementary food.

Positive attribute categories

There were five positive food attribute categories and six negative food attribute categories. The positive and negative categories had five categories in common: Nutrient Content, Effects on Child, Child's Response, Availability and Accessibility**,** Awareness of Availability of the Food, and Other Food Attributes.

Nutrient Content was an attribute category that emerged as a result of caregivers' descriptions of the key foods as having specific nutrient attributes that contributed to the child's intake, including protein, carbohydrates, fat, micronutrients, and minerals. These were deemed "necessary for the body" and proper growth.

Effects on Child was an attribute category that described something about the food that contributes to the well-being of the child. Caregivers characterized some foods as building nerves, helping the child's mind to be more awake, or helping with bones.

Child's Response to the food generally affirmed that the child liked the key home food. This attribute category infrequently encompassed attributes such as how the child liked a particular food; for example, a caregiver described the child liking plantains "green and ripe."

The fourth attribute category, Availability and Accessibility, dealt with affordability of a food, seasonal issues, and whether a food could be bought locally.

The Other Food Attributes category consisted of attributes conveying properties of food that did not necessarily affect the child.

Examples of the attributes from each of these categories are listed in **table 1** for home foods and **table 2** for manufactured foods.

TABLE 2. Positive attribute categories and examples of attributes of manufactured foods

Attribute category	Description	Examples of attribute
Nutrient content	Caregiver describes food as having specific nutrients (protein, carbohydrates, fat, micronutrients, minerals, calories, water)	It has vitamins It has iron It's fortified It has zinc and folic acid
Effects on child	Something about the food helps the child grow healthy or does not affect the child's growth negatively	It helped the child gain weight It's balanced It fills the child up so she doesn't wake up at night Gerber prune helps with constipation They are especially for children It's complemented Supplementary It's very good for malnourished children It helps the child get used to different flavors It has vegetables that are good
Child's response	Whether the child likes the food; characteristics of the food the child likes	The child liked the rice-flavored cereal The child likes Nestum but not Gerber cereal The child likes it because it's a puree The child likes sweet things The child ate it more quickly than shredded fruit
Availability and accessibility	Available relatively nearby; affordable prices	You spend less on it because it already contains milk It's not expensive It's controlled, only given to malnourished The health post provides an alternative gruel from Progresa which the doctor says is the same as Progresa It's sold everywhere I don't know it/never seen it
Other food attributes	Given by caregiver, not necessarily related to effect on child	It's easy to use (just add water) It's tasty It's pure fruit It's more hygienic than fruit It's not risky because it doesn't have coloring

Negative attribute categories

There were six negative food attribute categories; five were the same as the positive food attribute categories, and the sixth was Food Quality and Safety.

Caregivers described the Nutrient Content of a food, particularly the fat content, as a negative attribute. Effects on Child emerged as a second category in which caregivers linked home foods with ill health, many of which were related to gastrointestinal problems. Child's Response described negative responses the child had to the home foods, while affirming the child's dislike of the food. Sometimes a child enjoyed a food that she or he did not enjoy previously. Availability and Accessibility attested to increased prices of foods and seasonality issues that made a food unavailable.

Food Quality and Safety was the one attribute category that was not among the positive categories. This category concerned issues caregivers had with how safe a food was for the child as well the characteristics of a food that might make it unsafe for the child. The final food attribute category, Other Food Attributes, included attributes conveying properties of food that did not necessarily affect the child.

Examples of the attributes from each of these categories are listed in **table 3** for home foods and **table 4** for manufactured foods.

TABLE 3. Negative attribute categories and examples of attributes of home foods

Attribute category	Description	Examples of attribute
Nutrient content	Caregiver describes food as having specific nutrient (fat)	It has cholesterol Sometimes they have too much fat
Effects on child	Something about the food affects child growth negatively	It's too strong for the child It's too heavy They're dangerous (eggs) If given too much it causes jaundice It causes eczema The skin can cause indigestion The skin can cause a stomachache They can cause pain It causes constipation The seeds make a rock in the stomach Too much banana causes hepatitis
Child's response	Negative responses the food elicits in the child; the age at which the child disliked the food and when that changed	The child doesn't like it The child didn't like it at 4 months but liked it at 11 months It makes the child vomit The child can be repulsed by it, so it must be fed in small bits
Availability and accessibility	Available relatively nearby; seasonally available; affordable prices	Beans are more expensive than rice It's not very cheap Can't always buy it It's the fruit that the mother buys most It's hard to get when it's not in season The mother has to spend too much on sugar (because oranges are sour)
Food quality and safety	Characteristics of food that make it unsafe for child	Chickens are given too many hormones to make them fat; they are not allowed to develop by themselves Chickens grow too quickly—bad for child Chicken nowadays has a lot of blood and bruises; if it didn't have so much blood, it would be nutritious for babies It's not natural (i.e., it's artificial) It has a bad odor It has hormones
Other food attributes	Given by caregiver, not necessarily related to effect on child	The ones they sell in the *tienda* taste like medicine It doesn't have the same flavor as it used to

Home foods

Of the three protein-rich home foods (chicken, eggs, and beans), caregivers were most receptive to chicken (**table 5**). Twelve of the 21 Nutrient Content attributes regarding chicken described it as having protein; this attribute was shared widely in Jamaica. Six of 24 caregivers in Panama attributed affordability to chicken. The negative attributes of chicken revolved around the artificiality of chicken, including concerns regarding injected hormones that caused the chickens to become "unnatural" and overly fat.

Although 15 of the 24 Nutrient Content attributes acknowledged that eggs or some part of the egg has vitamins, there was a large degree of concern for its effects on the child. Eggs were associated with many illnesses, including boils, jaundice, indigestion, eczema, and "hardening of the arteries." Caregivers in Brazil believed that eggs were too "heavy" or "strong."

Iron, vitamins, and protein were some of the nutrients attributed to beans, especially in Brazil and Jamaica. The negative attributes of beans were reported more commonly in Mexico and Panama, where bean skins were believed to be especially associated with gastrointestinal problems.

Of the non-protein-rich home foods, caregivers were most receptive to carrots. Thirty-four caregivers attributed vitamins to carrots, and 30 caregivers (including all of the caregivers in St. Catherine, Jamaica) believed that carrots were "good for the eyes or vision." Carrots had fewer negative attributes than any other home foods.

TABLE 4. Negative attribute categories and examples of attributes of manufactured foods

Attribute category	Description	Examples of attribute
Nutrient content	Caregiver describes food as having specific nutrients (protein, carbohydrates, fat, micronutrients, mineral, calories, water)	It has few vitamins It has vitamins, but it's better that they be natural It has too much starch It has too much maize and fat It's bad that it has so many carbohydrates
Effects on child	Something about the food affects child growth negatively	Milk causes allergy Milk will make the child a fool The baby is lactose intolerant It has chemicals that can affect the child's health sooner or later It causes diarrhea It has preservatives and that may have consequences or be harmful (so shouldn't feed frequently) Some children get sick because the food is processed and has chemicals A friend said it was harmful because it comes out in the blood
Child's response	Characteristics of the food the child dislikes	The child doesn't like gruels The child doesn't like tinned food The child doesn't like oat-flavored cereal
Availability and accessibility	Available relatively nearby; affordable prices	It's too expensive It's hard to get The mother doesn't want to take the risk that her child won't like it, so she doesn't buy it It's cheaper to make homemade purees You have to prepare it with milk, and sometimes the mother doesn't have money to buy milk
Food quality and safety	Characteristics of food that make it unsafe for child	If the child doesn't eat it right away it turns "waxy," even when it is kept in the refrigerator It's not natural; it's artificial It has coloring When it's processed it doesn't really have vitamins You have to watch the expiration date
Other food attributes	Given by caregiver, not necessarily related to effect on child	It doesn't look good; it doesn't interest me Doesn't like any form of tinned food The mother feels that tinned foods aren't nourishing

TABLE 5. Summary of attributes of each key home food

Food	Positive attributes	Negative attributes
Chicken	Protein "Nourishing" effect on child Child likes chicken	"Sometimes they have too much fat" Concern for the "artificiality" "Chicken nowadays has a lot of blood and bruises"
Eggs	Has vitamins Centered around the word "good," more specifically, contributing to child's health, in terms of growth of both bones and the brain "Cheap" and "economical" in Panama	"It has cholesterol" More negative attributes for Effects on Child Associated with illness: boils, jaundice, etc. Concern about eggs being too heavy or strong Fewest negative attributes from Panama
Beans	"They have iron" "They have vitamins" "They have protein" General idea that beans are good "Nutritious"	Many negative attributes; gastrointestinal problems Skin is associated with stomachache and diarrhea, in addition to being hard to digest "Beans are expensive (more than rice)" in Panama
Carrots	Vitamins "They are good for the eyes or vision"	Very few negative attributes, none for nutrient content "They cause constipation"
Bananas and plantains	"Iron," overwhelmingly in Jamaica Very scattered positive attributes for effect on child, but general consensus that "They're nourishing, good for the blood," etc.	Some concern regarding constipation Some concern regarding the seeds in bananas: "Seeds make rock in stomach," "Eating seeds causes constipation," "It's bad for the child if you do not remove the seeds"
Oranges	Vitamin C Associated with treating illnesses: good for anemia, flu and colds, constipation, disorders of intestines and stomach	In Jamaica, concern about fever Some association with gastrointestinal problems: if child has diarrhea, the stool becomes more loose; oranges cause vomiting and gastric problems; oranges cause diarrhea

Caregivers, particularly those in Jamaica, believed that bananas and plantains contained iron. Although there were variable positive attributes expressed for Effects on Child, there was a general consensus that bananas and plantains contributed to the child's health and strength. Negative attributes included the concern that banana seeds could cause constipation in children.

Thirty-five caregivers believed that oranges contained vitamin C. Oranges were believed to have both positive and negative attributes: some caregivers thought that oranges were good for treatment of illnesses such as anemia, flu and colds, and constipation, whereas others associated oranges with gastrointestinal problems.

Manufactured foods

Caregivers gave less detailed accounts of the manufactured foods than the home foods, which suggests that they were more familiar with home foods. Most manufactured foods were associated with few attributes, and the attributes caregivers ascribed to them varied from person to person and site to site. The positive attributes of manufactured foods mainly concerned Nutrient Content ("It has vitamins," "It's nourishing") and Effects on Child ("It's good for children," "It helps the child grow"). The negative attributes of manufactured foods mostly concerned their processed quality, which made them less nutritious ("When it's processed it doesn't really have vitamins").

Discussion

Complementary feeding is essential for good nutrition and health in young children. The most direct way to prevent inadequate complementary feeding is to ensure that caregivers provide their children with complementary foods rich in nutrients and energy and feed them appropriately. The Nutrient Content of a food, however, is not its only attribute, and understanding the attributes that caregivers assign to foods is important in improving complementary feeding. This study aimed to understand attributes that caregivers assign to complementary home and manufactured foods at eight sites in four Latin American and Caribbean countries.

The home foods studied were chosen to be common across the eight sites, but the manufactured foods differed from country to country. Key home and manufac-

tured foods had both positive and negative attributes. The positive attribute categories were the same for both the home and the manufactured key foods: these included Nutrient Content, Effects on Child, Child's Response, Availability or Accessibility, and Other Food Attributes. The negative attribute categories were also common to both home and manufactured foods, and they included Food Quality and Safety in addition to the positive categories.

Caregivers thought about manufactured foods similarly to the way they thought about home foods. The Food Quality and Safety attribute expressed concerns about the composition of foods. With home foods, there was concern that the foods contained too many hormones, whereas with manufactured foods, there were concerns that a food was artificial or that it had lost its vitamins from being processed. The attributes identified suggest that caregivers have been influenced both by traditional ideas about foods and by information and ideas from the media and other sources.

Future programs can use the attribute categories this study has uncovered to gain a better understanding of specific food attributes. Using these categories for discussion in local focus groups or in questionnaires would reveal what aspects of nutrition education are needed. Programmatically, more specific questions have the advantage of clarifying where there may be beliefs about attributes or gaps in caregivers' knowledge regarding the nutrient content of a food or the effects a food has on a child's health.

There may be attribute categories that our analysis did not identify. Our list of attributes is not exhaustive, since there may have been attributes particular to a location that our analysis did not draw out because we were primarily looking for common attributes across four countries. Furthermore, the category Other Food Attributes implies that there were manifestations that did not fit into the five attribute categories that we identified.

This study found that of the three home protein-rich food, caregivers were most receptive to chicken. Since animal-source foods markedly improve the well-being of children [3], chicken may be useful in complementary feeding programs in Brazil, Jamaica, Mexico, and Panama. Of the three other home foods, caregivers were most receptive to carrots, which implies that in regions where vitamin A deficiency may be a serious concern, caregivers can be encouraged to feed their children carrots.

Although some caregivers recognized that manufactured foods are often fortified with nutrients to help their children grow and be healthy, other caregivers associated processed foods with artificial qualities, loss of nutrients, and ill effects. To encourage the use of manufactured foods in Latin America and the Caribbean, educational programs may be needed. In addition, the cost of manufactured foods is likely to be a barrier to many caregivers unless specific efforts are made to develop and market low-cost foods.

Complementary feeding is a complex behavior that involves not only foods with appropriate attributes, but also appropriate feeding behavior and feeding environments. The *Guiding Principles for Complementary Feeding of the Breastfed Child* [17] describes ideal complementary feeding practices, such as the continuation of breastfeeding when complementary foods are introduced. These guiding principles should be accompanied by responsive care behavior [18–20]. It is important to recognize that "Children who live in difficult conditions are dependent on the nurture of primary caregivers to shield them from the most threatening features of their environment," because "Warm and responsive caregiving extends protection to children in otherwise adverse situations" [19]. Pelto et al. suggested a set of "best-practice complementary feeding behaviors" and systematically discussed who feeds the child, what complementary foods are given, when and where they are given, and how they are prepared and given [18].

This study provides information about the appropriate attributes of a food according to the caregivers' perspectives. It provides guidance as to how such studies should be conducted in the future and describes attributes that are important for program planning. The results of the study affirm the importance of acknowledging that the caregivers ultimately have control over what complementary foods are fed to their children.

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Weaning foods and their impact on child-feeding practices among low-income Nigerian mothers

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Abstract

Background. *Many children in rural communities of developing countries die of nutrition-related causes due to lack of nutrition education and low purchasing power of the families, which result in low-quality weaning foods and poor feeding practices.*

Objective*. To evaluate the nutritional composition of local weaning foods and their impact on child feeding practices among low-income Nigerian mothers.*

Methods. *A cross-sectional survey was conducted between March and June 2005 among 294 randomly selected pairs of nursing mothers and their children who attended the postnatal clinic of State Specialist Hospital and Comprehensive Health Centers in Akure community, Ondo State, Nigeria. A structured, self-or interviewer-administered questionnaire was used to collect information on infant demographic characteristics, feeding, and socioeconomic characteristics of the parents. The children's weights were recorded, and samples of the weaning foods were analyzed.*

Results. *The mothers' ages ranged from 22 to 37 years, and the children's from one to 12 months. Among the parents, two-fifths of the respondents worked as drivers, mechanics, carpenters, and the like, while the remaining respondents were civil servants, health professionals, teachers, merchants, and housewives. The educational attainment of the parents ranged from no formal education (1.4%) to higher education (46%); 13% had completed primary school, and 39.6% had completed secondary school.*

The average monthly family income was between 3,500 and 30,000 naira (US$23.3–$200). Among the children, 58.3% were of normal weight, 41.1% were mildly underweight, 0.3% moderately underweight, and 0.3% severely underweight; 23.1% were exclusively breastfed, 9.5% received breastmilk and traditional medicinal herbs, 15.6% received breastmilk and commercial weaning food, 7.4% received commercial weaning food only, 14.8% received local weaning foods only, 24.1% received local weaning foods plus breastmilk, and 5.8% received the family diet.

Conclusions. *We found that a high proportion of the nursing mothers used local ingredients to formulate weaning foods for their babies. The nutritional compositions of these foods is of high quality and are suitable as weaning foods, particularly for infants of low-income parents who do not have access to commercial weaning foods.*

Key words: Child-feeding practices; nutritional composition of local weaning foods; nutrition education

Introduction

Ignorance and food taboos can result in poor weaning practices among nursing mothers in developing countries. Improving the nutritional value of weaning foods by itself will not eliminate the problems of poor weaning practices. Training and providing qualitative nutrition education to mothers is necessary to change feeding practices and to improve the quality of the children's diet during weaning. Nutrition education messages generally address a nutritional problem (deficiency or excess) that has been identified in the population. The messages aim to change the eating practice that is considered to be the cause of the nutritional problem. For effective implementation, nutrition education can easily be incorporated into primary health-care programs. Health workers and nutritionists can educate rural mothers about the importance

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of breastfeeding practices, quality weaning food, and good hygiene when handling and preparing the baby's food. Research has shown that giving adequate nutrition education to mothers, particularly in developing countries, improves the nutritional and health status of children [1], and reduces the prevalence of malnutrition in some developing countries.

Ogi, a gruel made from fermented sorghum or corn (maize), is a commonly used traditional weaning food in Nigeria. Ogi is prepared by soaking corn in cold water for four or five days, after which it is wet milled and sieved. Ogi contains only 0.5% protein and less than 1% fat, as compared with 9% protein and 4% fat in the original corn [2]. The protein content of ogi is too low even to support the growth of rats [3]. It has been reported that ogi can provide some energy (415 kcal/100 g) but not enough of the other nutrients needed for the growth of a baby [4]. Studies have reported that during the preparation of ogi (sorghum gruel) many nutrients other than protein are lost, and that 98% of the tryptophan is lost during the processing of ogi [5, 6]. There is a high incidence of nutritional problems in areas where ogi is the major weaning food [5, 6]. To improve the nutritional composition of ogi, other protein-containing foods, such as soybeans and crayfish, need to be added.

The family diets to which some infants are weaned are also low in nutritional value. Many investigators [3, 7, 8] have reported that the majority of traditional foods are low in protein and that other nutrients are lost because of poor processing. Bulk is a major problem of the traditional West African weaning foods [9–11]. For adults and older children, it is usually possible to achieve an adequate intake of protein and energy by increasing the daily intake of starchy foods of low nutrient density. This is not possible for infants and small children because of the small size of their stomachs and the large volume of traditional foods that must be ingested to cover energy needs [12]. However, the use of foods of high nutrient density and frequent feeding schedules can help provide adequate food for growth and activity. The problems inherent in the traditional weaning foods and feeding practices predispose the infant to malnutrition, growth retardation, infection, and high mortality. Studies have shown that one major cause of malnutrition during the weaning period is the low quality of weaning food given to the child when breastmilk is no longer meeting its nutrient requirements [13, 14]. Protein–energy malnutrition is common among infants and children in the lower socioeconomic groups of developing countries. Because of socioeconomic factors, taboos, and ignorance, people from low-income groups seldom give high-quality weaning food to their children [1, 15–16]. Severe protein-energy malnutrition results in growth retardation and poor cognitive development [17–19]. Furthermore, malnutrition among weaning children in developing countries predisposes them to various infectious diseases, such as diarrhea, whooping cough, and acute respiratory infections [20].

Solving the problems associated with weaning foods in Nigeria may involve improving the quality of traditional weaning foods, ensuring household food security, providing nutrition education, and improving the income-generating capacity of women. Traditional weaning foods might be improved by combining them with locally available foods that complement each other in such a way that the new pattern of amino acids created by this combination is similar to that recommended for infants [21]. The aim of the present study is to assess the feeding practices of low-income nursing mothers and to determine the nutritional composition of the local weaning foods used.

Materials and methods

Study areas and center

Akure community is situated in Ondo State, Nigeria. The area is one of the commercial centers of the state. One-third of the land area is used to grow agricultural products such as cocoa and food crops (in which nearly 80% of the working population is involved). The study was carried out at the community health center attached to the State Specialist Hospital and Comprehensive Health Centers in Akure community.

Ethical issues and informed consent

The study protocol was approved by the ethics committee of Food and Human Nutrition of the Federal University of Technology in Akure, Nigeria. The mothers were briefed about the details of the study. They were informed that their participation in the study was voluntary, the study would not cause any harm to their children, and there was no penalty for those who declined. The consent forms were then distributed to those mothers who volunteered to participate in the study to sign.

Data collection

Sampling methods

This cross-sectional study was conducted between March and June 2005. The sample frame consisted of all mother–child pairs who attended the community health center section of the hospital; 302 mother–child pairs were recruited for the study. Eight pairs dropped out after the first meeting for personal reasons, and 294 respondents completed the study. A structured, self-administered questionnaire (in both the local language

and English) was administered to subjects to collect information on the family's socioeconomic status, demographic characteristics of the baby, breastfeeding, and weaning foods. Researchers orally administered the questionnaires to mothers who were illiterate.

Socioeconomic status

The socioeconomic status of the family was evaluated by a standard method [22]. Characteristics such as education, occupation, and monthly income of the father and mother were considered.

Anthropometric measurements of the children

The children were weighed at the beginning of the study and weekly thereafter for 4 months to ascertain if they were growing normally and whether the mother was using the knowledge acquired from the clinic [23, 24]. Weight was measured to the nearest 0.1 kg by gently placing the child in the middle of the bowl of portable beam balance scale (Hana, Br-90011) wearing light clothing and without shoes. Each child was weighed twice, and the mean of the measurements was calculated and related to the weight-for-age z-score. A validation study has provided support for the use of the weight-for-age z-score, a measure of underweight in children, as one of the most appropriate nutritional indexes for evaluating past and current malnutrition in children [26].

Nutrition education

During weekly visits to the clinic, the mothers were educated about the importance of exclusive breastfeeding and formulation of protein-rich weaning diets from local food materials. Methods of preparing these weaning foods were demonstrated to the mothers, with their full participation. After preparation, the meal was usually served to the weaning child. The nutrition education program was initiated by the government for the postnatal clinic because of the high prevalence of malnutrition among children 4–12 months due to poor feeding practices among the nursing mothers.

Children's dietary intakes

Home dietary intake

The dietary intake of the children was evaluated by the 24-hour dietary recall method in order to determine whether the nursing mothers were practicing what they learned at the postnatal clinic.

Clinic day dietary intakes

At every clinic, the health officials, with full involvement of the attended nursing mothers, prepared a weaning recipe, such as soy–moinmoin, beans, soy–ogi, or crayfish–ogi. After preparation, the meal was usually served to the weaning aged children in order to complement their home daily intake; although the quantities of food eaten at the clinic by these children were not measured during the study.

Preparation and chemical analysis of food samples

Food samples

The ingredients and methods of preparation of the weaning foods for this study were provided by the health officials of the community health section of the hospital, although the ingredients (sorghum [*Sorghum bicolor*], soybean [*Glycine max*], crayfish (*Procambarus acutus*), beans [*Vigna unguiculata*], commercial powdered milk and other ingredients, like onion, pepper etc.) were locally available in the community market at affordable prices. Equipment such as blenders and pots for the processing of sorghum, soybean, beans, and crayfish flours were locally available, and the method of preparation was a familiar one to the mothers.

Preparation and processing methods

Soybean flour. Soybean seeds were washed and soaked in 0.5% sodium hydrogen carbonate solution at a temperature of 30°C for 2 hours. The seeds were cooked for 30 minutes at a temperature of 100°C. The seeds were dehulled and dried at 60°C for 24 hours in an air-drought oven. The dried seeds were milled with a laboratory hammer mill (DIETZ-7311 Dettingen-Teck) and then sieved through a 0.4-mm mesh screen. The soybean flour was kept in airtight containers prior to chemical analysis.

Sorghum flour. Sorghum was sorted to remove impurities, washed with clean water, and soaked in water for 5 days. After soaking, it was thoroughly rinsed with clean water and drained. The clean samples were then dried at 60°C for 24 hours in an air-drought oven. The dried seed was processed and stored as described above.

Bean flour. The bean seeds were sorted by removing stones and other impurities, washed, and soaked in ordinary water for 20 minutes. The seeds were then dehulled and dried at 60°C for 24 hours in an air-drought oven. The dried bean flour was processed and stored as above.

Crayfish flour. Dried crayfish was purchased from the local market and sorted to remove impurities. The crayfish was further dried at 60°C for 24 hours in an air-drought oven. The dried crayfish were processed and stored as described above.

Milk. Commercial dried cow's milk (123 Peak Milk brand) was purchased from the local market. This milk is specially formulated for growing children aged 6 months and above, and many families belonging to low-income group could afford it.

Food formulation and preparation

Soy–sorghum, crayfish–sorghum, and milk–sorghum flour. These blends were mixed as follows: soy–sorghum consists of one part soybean to four parts sorghum flour (1:4); crayfish–sorghum one part crayfish to nine parts sorghum flour (1:9); and milk–sorghum one part powdered milk to nine parts sorghum flours (1:9). Each blend (200 g) was mixed with 40 ml of water to form a smooth paste. Boiled water (750 to 1,000 ml) at 100°C was then slowly mixed with the sample and stirred continuously until a homogeneous gel of a desirable thickness was formed.

Soy–moinmoin (bean and soybean flours). Bean and soybean flour were mixed at a ratio of 3:1, and the blend (200 g) mixed with water (30 ml), salt (5 g), ground pepper (1 g), onion (4.0 g), and vegetable oil (1.5 g). The mixture was put into an aluminum pot and cooked on an electric hotplate for 45 minutes.

Cooked beans. Beans (250 g) were dehulled to improve their digestibility and cooked on an electric hotplate with water (150 ml), salt (1 g), onion (5 g) and vegetable oil (2.5 g) until tender.

Chemical analyses

The chemical composition of the soy–ogi, crayfish–ogi, soy–moinmoin, and cooked beans was determined. The chemical composition of the cerelac was not determined, but the information on the chemical composition of cerelac was considered as labeled by the manufacturer. The methods of sample treatment and analyses were the standard procedures recommended by the Association of Official Analytical Chemists [27]. Moisture content was assayed by loss of weight on drying at 60°C in a hot-air circulating oven (Gallenkamp). Ash was determined by incineration of known weights of the samples in a muffle furnace (Gallenkamp, size 3). Crude fat was determined by exhaustively extracting a known weight of sample in petroleum ether (boiling point, 40° to 60°C) in a Soxhlet extractor. The ether was volatilized and the dried residue was quantified gravimetrically and calculated as percentage of fat. Protein (N × 6.25) was determined by the Kjeldahl method. Crude fiber was determined after digesting a known weight of fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide. The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash, and fat from the total dry weight (100 g) of the food sample differences. The gross energy was determined with a Gallenkamp ballistic bomb calorimeter.

Determination of mineral content

Sodium and potassium contents were determined by flame photometry with a Jenway photometer, and phosphorus was determined by the vanado-molybdate method [27]. The calcium, magnesium, zinc, copper, lead, aluminum, and iron contents were determined after wet digestion with a mixture of nitric, sulfuric, and hydrochloric acids by atomic absorption on an ash sample using a Buck Model 200A flame atomic absorption spectrophotometer.

Statistical analysis

The socioeconomic and nutritional status distributions of the subjects were expressed in frequencies and percentages. These analyses were performed by a GenStat 6.1 (2002) computer program.

Results and discussion

Two hundred ninety-four mother–child pairs were recruited for the study. Approximately half (50.4%) of the children were between age 0 and 4 months. The high proportion of children in this age group could have an impact on the distribution of the nutritional status of the children, since these children would not have eaten much of the formulated diets as yet. It was observed in this study that two-fifths of the children were malnourished; investigators reported a similar observation that infants and small children cannot consume enough of the traditional foods to cover all of their nutritional needs because of the large volumes that would be required [12].

Table 1 shows the socioeconomic characteristics of the subjects' parents. More than one-quarter of the parents worked as civil servants, health-care providers, or teachers; others were traders, farmers, or housewives

TABLE 1. Socioeconomic characteristics of the infants' parents (%)

Characteristic	Families (N = 294)
Occupation	
Housewife	0.7
Civil servant	15.6
Health-care professional teaching	2.1
Teaching	11.1
Trading	27.6
Farming	2.2
Vocational jobs (driver, mechanic, etc.)	40.8
Education	
None	1.4
Primary	13.0
Secondary	39.6
Tertiary	46.0
Monthly income (Naira)	
≥ 7,500	28.4
7,500–15,000	25.7
15,000–22,000	17.1
22,000–30,000	15.7
> 30,000	13.0

a. 150 naira = US$1.

or had vocational jobs such as driver or mechanic. Almost half of the parents had tertiary education. The monthly income of the families ranged between 3,500 and 30,000 naira, and more than two-thirds of the parents earned less than 22,000 naira ($147) a month. In this study we observed that a large proportion of the studied families were poor, possibly because many of these families did not have a great deal of education and worked in low-wage occupations. This observation was similar to other findings that reported high prevalence of poverty in developing countries [28]. Several studies have reported strong correlations between low income and poor feeding practices and health status [28–32]. Studies have also found that poor feeding practices have a detrimental effect on the health and nutritional status of vulnerable groups of people, particularly children, and that this can be corrected by nutrition education [33, 34].

Nutritional status serves to identify individuals at risk and those individuals or groups of children whose nutritional status ought to be improved. In the present study, the nutritional status of the children was evaluated by weight-for-age z-score, and it was observed that 58.3% of the children were of normal weight, 41.1% were mildly underweight, 0.3% were moderately underweight, and 0.3% were severely underweight (**table 2**). The large proportion of children who were of normal weight could have been so as a result of adequate feeding practices by the mothers. Several studies have reported that adequate quality diets promote physical growth and cognitive development of children [35, 36].

Among children 4 months of age or younger, 23.1% were receiving breastmilk only and 9.5% were receiving breastmilk and decoctions of local medicinal herbs

TABLE 2. Distribution of infants' nutritional status

Nutritional status[a]	No. (%) of infants		
	Boys (N = 118)	Girls (N = 176)	Total (N = 294)
Normal	75 (63.2)	94 (53.3)	171 (58.3)
Mild underweight	43 (36.8)	80 (45.3)	121 (41.1)
Moderate underweight	—	1 (0.7)	1 (0.3)
Severe underweight	—	1 (0.7)	1 (0.3)

a. Nutritional status is defined by weight-for-age z score (WAZ). Normal weight, WAZ ≥ 0; mild underweight, WAZ = –1; moderate underweight, WAZ = –2; severe underweight, WAZ = –3).

TABLE 3. Dietary intake of the infants

Diet	No. sampled	% receiving diet
0–4 mo		
Breastmilk only	68	23.1
Breastmilk + herbal decoction	28	9.5
> 4 mo		
Breastmilk + commercial weaning food	46	15.6
Commercial weaning food only	22	7.4
Home-made weaning food only (soy–ogi, etc.)	42	14.8
Home-made weaning food + breastmilk	71	24.1
Other (family diet)	17	5.8

TABLE 4. Chemical composition of complementary foods (per 100 g)

Ingredient	Milk–ogi	Crayfish–ogi	Soy–ogi	Soy–moinmoin	Cooked beans	Cerelac[a]
Energy (kcal)	408.2	438.7	333.0	377.3	330.4	412.6
Moisture (g)	5.5	2.7	8.9	7.8	12.6	2.5
Protein (g)	16.9	22.1	10.8	30.4	24.4	15.0
Carbohydrate (g)	65.7	61.5	61.5	42.5	52.2	67.9
Fat (g)	8.6	11.6	5.0	9.6	2.0	9.0
Ash (g)	1.7	1.1	11.6	6.3	3.3	3.30
Crude fiber (g)	1.6	1.0	2.2	3.5	4.2	2.30
Vitamins and minerals						
Calcium (mg)	267.4	24.6	90.3	227	22.0	Not determined
Iron (mg)	4.2	4.0	9.8	17.4	11.3	Not determined
Lead (mg)	Not detected	Not detected	Not detected	Not detected	Not detected	Not determined
Phosphorus (mg)	267.8	216.8	107.5	410	124	Not determined
Vitamin A (IU)	16.0	0.0	0.0	37.5	50.2	Not determined
Thiamine (mg)	0.41	0.36	0.46	0.85	0.9	Not determined
Niacin (mg)	2.9	2.8	2.98	1.5	1.2	Not determined
Vitamin C (mg)	0.01	0.0	0.0	0.0	0.0	Not determined
Riboflavin (mg)	0.26	0.1	0.14	0.15	0.9	Not determined

a. Cerelac is a commercial weaning food.

twice a day. The diets of older children, age 5 months and older, typically consisted of a prepared weaning diet alone or with breastmilk (**table 3**). A high proportion of mothers stated that they breastfed their infants exclusively from immediately after birth up to 3 months or more before introducing a weaning diet. The reasons they gave were that breastmilk was natural, nutritious, and economical and would promote growth and development in the children. Other investigators from Nigeria and other developing countries have reported that rural mothers breastfeed their babies up to 3 or more years of age and have agreed that breastfeeding is an unequaled way of providing ideal food for the healthy growth and development of infants, and that the first milk or colostrum is of particular value to the infant because of its high content of proteins and fat-soluble vitamins and its anti-infective properties, which provide the infant with its first immunizations [34, 37, 38].

The composition (per 100 g) of the formulated local weaning foods varied over the following ranges: energy, 330.0–438.7 kcal; moisture content, 2.7–12.6 g; protein, 10.8–30.4 g; carbohydrate, 42.5–65.7 g; fat, 2.0–11.6 g; ash, 1.7–11.6 g; and crude fiber, 1.0–4.2 g. There were also appreciable amounts of minerals and vitamins (**table 4**). We observed that the nutritional compositions of these local weaning foods could possibly adequately support growth and development in children compared with the commercial weaning food (Cerelac), but since some of the recipes were deficient in some vital nutrients, the nutritional composition of the formula may not be as robust as expected. The average amounts of the formulated local weaning foods that would be required to meet the recommended dietary allowances (RDAs) of children aged 4 to 6 months and 7 to 12 months are shown in **table 5**. These amounts are much smaller than the amount of ogi not supplemented with milk, crayfish or soybean that would be required to meet the RDAs.

The costs of the ingredients used in formulating these local weaning foods were low enough to make them accessible to low-income mothers. In addition, all equipment required for their preparation were locally available. However, the amount of the formulated weaning foods required is larger than that of the commercial weaning foods because the commercial foods are fortified to provide a high density of nutrients. Several studies have developed high-quality weaning foods from local food materials that could provide adequate nutrients for growing children [39–41].

The prices of food materials (sorghum, soybeans, and crayfish) as purchased from the local market for the production of traditional weaning

TABLE 5. Average amount of formulated local weaning foods (grams) required to meet the recommended dietary allowance (RDA) of the infants[a]

Nutrient	4–6 mo						7–12 mo					
	RDA	Milk–ogi	Crayfish–ogi	Soy–ogi	Soy–moinmoin	Cooked beans	RDA	Milk–ogi	Crayfish–ogi	Soy–ogi	Soy–moinmoin	Cooked beans
Energy (kcal)	820	201	187	246	217	248	820	201	187	246	217	248
Protein (g)	9.1	53.8	41.2	84.3	29.9	37.3	11.0	65.1	49.8	102	36.2	45.1
Carbohydrate (g)	60	91.3	97.6	97.6	141	115	95	145	154	154	224	223
Fat (g)	31	360	267	620	323	1550	30	349	259	625	313	1,500
Calcium (mg)	210	78.5	85.4	233	92.5	955	270	101	1144	299	119	1,227
Iron (mg)	0.27	6.4	6.8	2.8	1.6	2.4	11	262	275	112	63	58.5
Phosphorus (mg)	100	37.3	46.1	93.0	24.4	80.6	275	103	127	256	67.1	222
Vitamin A (IU)	400	2,500	0.0	0.0	1,066	797	500	3,225	0.0	0.0	1333	99.6
Thiamine (mg)	0.2	48.8	55.5	43.5	23.5	22.2	0.3	73.2	83.3	652	35.3	33.3
Niacin (mg)	2.0	69.0	71.4	67.1	133	167	4.0	138	142	134	267	333
Vitamin C (mg)	40	0.00	0.0	0.0	00.0	0.0	50	0.0	0.0	0.0	0.0	0.0
Riboflavin (mg)	0.3	115	300	214	200	33.3	0.4	154	400	286	267	44.4
Lead (mg)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

a. Amount required to meet RDA = (RDA × 100)/amount of nutrient per 100 g.
NR, no requirement
Source: [41].

foods ranged between 98 and 200 naira; these prices were lower than those of commercial weaning foods, which ranged between 400 and 1,500 naira (**table 6**). Low-income families cannot afford to purchase these commercial weaning foods [42], and for these families an alternative low-cost weaning formula is warranted.

Conclusions

This study found that a high proportion of the nursing mothers utilized local food ingredients to formulate weaning foods for their babies. The nutritional composition of these foods is of high quality, and they are suitable as weaning foods, particularly for infants from low socioeconomic level families who do not have access to commercial weaning foods.

TABLE 6. Comparative cost of production of home-made weaning foods and commercial weaning foods

Food	Weight (g)	Production cost (naira[a])	Production cost (g/naira[a])
Home-made weaning foods			
Milk–ogi	500	195	0.39
Crayfish–ogi	500	200	0.40
Soy–ogi	500	150	0.30
Soy–moin-moin	500	98	0.196
Cooked beans	500	100	0.02
Commercial weaning foods			
Nutrend	400	400	1.00
Cerelac	450	450	1.00
Nan	450	650	1.44
SMA Gold	450	1,500	3.33
SMA	450	800	1.78
123 Peak Milk	500	450	0.90

a. 150 naira = US$1.

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Econutrition: Implementation models from the Millennium Villages Project in Africa

Richard J. Deckelbaum, Cheryl Palm, Patrick Mutuo, and Fabrice DeClerck

Abstract

Econutrition integrates environmental health and human health, with a particular focus on the interactions among the fields of agriculture, ecology, and human nutrition. Soil loss and degradation and human undernutrition are major barriers to economic development in Africa. A primary aim of the Millennium Villages Project in Africa is to meet the Millennium Development Goals by integrated multisectoral interventions in health and nutrition, agriculture, and environmental sustainability in hunger and poverty hot spots in Africa. Econutrition is only one example of how interdisciplinary approaches are not only critical to alleviating extreme poverty but also fundamental to linking basic science understanding in multiple areas. Human health and agricultural productivity gain, and the costs of the gains are lowered, when we take the opportunity to apply different disciplines through cross-sectoral, thematically linked interventions.

Key words: Africa, ecology, econutrition, Millennium Villages Project, nutrition

Econutrition: Definition and rationale

The dictionary definitions of ecology as "the interrelationship of organisms in their environment" and nutrition as "the act or process of being nourished" are commonly known. However, no dictionary definition can be found for "econutrition." Thus, the concept of integrating the terms of ecology and nutrition into econutrition is relatively recent. A good introduction to the concepts of agricultural systems that provide more nutritious foods, a major component of econutrition, can be found in Kataki and Babu [1]. For the framework of this paper, econutrition will be defined in terms of the interrelationships among nutrition and human health, agriculture and food production, environmental health, and economic development. **Figure 1** illustrates how adverse interactions among health, agriculture, and environment are critical contributors to poverty in Africa, as well as in other developing areas. The vicious cycles that lead to loss of nutrients, soil erosion, and decreasing biodiversity link into environmental degradation that results in decreased food production. Lack of food is associated with malnutrition and illness and especially with declining labor productivity, which exacerbates poor agricultural management.

Although undernutrition in developing regions such as Southeast Asia, East Asia, and Latin America is predicted to decrease substantially by the year 2015,

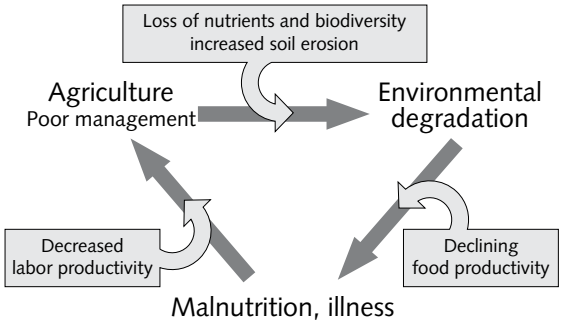

FIG. 1. The cycles of agricultural mismanagement, agricultural degradation, and malnutrition, demonstrating the interdisciplinary nature of econutrition. For development interventions to be successful, they must target and understand the interactions among the three disciplines

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estimates for sub-Saharan Africa indicate an increase in both the percentage and the absolute number of undernourished people. According to a 2001 report from the Food and Agriculture Organization, there is evidence that "46 million years of productive, disability-free life were lost in 1990, the result of lost social productivity caused by four types of malnutrition: stunting and disorders related to iodine, iron, and vitamin A deficiency" [2]. Every year, 3% of gross domestic product (GDP) is lost in some developing countries because of productivity losses resulting from nutritional deficiencies [3]. Only 36 of 58 (62%) non-oil-producing countries with annual per capita incomes below $3,000 were able to escape the poverty trap in recent decades. One of the defining characteristics that sets these successful countries apart from the 22 that remained poor is an investment in agricultural productivity in the form of improved seed and increased fertilizer use during the 1980s [4]. Countries starting with low cereal yields experienced economic decline between 1980 and 2000, whereas countries that invested in agricultural production had high economic growth rates [4]. Agricultural productivity and human nutritional well-being are inextricably linked to the economic growth of nations.

Econutrition integrates environmental health and human health with a particular focus on the interactions among the fields of agriculture, ecology, and human nutrition. As Alexander Von Humboldt said, "In the great chain of cause and effects, no thing and no activity should be regarded in isolation,"* and this is particularly true of econutrition. The use of nitrogen-fixing plants in agricultural systems provides an example understood by all disciplines. Nutritionists and vegetarians know that peanuts, tofu, and beans are important sources of protein that can replace animal sources. This comes as no surprise to agronomists or ecologists, who recognize that all three of these foods come from a unique plant family, the legume family, or Fabacaeae, which are major drivers of nitrogen cycling in terrestrial ecosystems and are tied to increased productivity in natural systems [5].

Although 80% of our atmosphere is composed of nitrogen, none of this is available to plants, and most soils, including those in sub-Saharan Africa, are nitrogen-limited. A unique association with bacteria found in the roots of most legumes allows the plant to convert atmospheric nitrogen into ammonium, a form usable by plants. This ability to capture and convert atmospheric nitrogen (N_2) to ammonium (NH_4^+), the foundation of amino acids and thus of proteins, is what makes legumes desirable from a nutritional perspective, as well as from the agricultural and ecological perspectives. The incorporation of legumes into agricultural systems can add up to 200 kg of nitrogen per hectare, restoring nutrients to depleted soils, boosting agricultural productivity, and providing human populations with plant-based protein. The etymological root *ammon* illustrates this connection: ammonium fertilizer for agronomists and amino acids for nutritionists. Interactions between healthy agroecosystems and healthy people such as this form the foundation of econutrition.

Costs of poor crop yields and undernutrition

Crop yields are correlated with GDP [4], and dietary energy supply per capita is closely linked to GDP per capita [2]. For example, Croppenstedt and Muller [6] estimated that in Ethiopia, an increase in body-mass index of only 10% would be associated with a 23% increase in work output and a 27% increase in average wages. The costs of iron-deficiency anemia, iodine deficiency, and vitamin A deficiency in terms of human development, productivity, and economics are immense. It has been estimated that the ratio of return on investment to costs for growth-promotion and micronutrient programs varies from 7:1 to 84:1 [7]. In Ethiopia, the estimated prevalence of iron deficiency is 85% among children and 58% among pregnant women; subclinical vitamin A deficiency is present in 30% of the population and goiter in 23%. In Kenya, 60% of children and 43% of women are estimated to be iron deficient, and 70% have subclinical vitamin A deficiency [8]. Thus, both macronutrient malnutrition and micronutrient malnutrition are far too common in Africa and need to be addressed by innovative, integrative approaches in econutrition.

To adequately feed people a diverse diet, about 0.5 hectare (1 hectare = 2.47 acres) of arable land per capita is needed, yet only 0.27 hectare per capita is available. In 40 years, only 0.14 hectare per capita will be available because of loss of land and rapid population growth. In Sauri, the Millennium Village in Kenya, the area available for crops is 0.33 hectare per family, or 0.06 hectare per capita. In many regions, as in Sauri, limited availability of land is a major cause of food shortage and undernutrition [9, 10]. Land shortage is compounded by land degradation. Whereas in developed countries land degradation carries an additional monetary cost, in developing countries, where financial resources are scarce, the cost is borne by the health and productivity of the population [11].

The cost of soil erosion can be estimated by measuring the cost of replacing lost water and nutrients on agricultural land. Additional costs of soil erosion occur in the form of off-site damage to recreation, human health, private property, navigation, facilities for water storage, conveyance, and treatment, etc. Calculations for several African countries made by Ballard and

* Barbour MG, Burk JH, Pitts WD, Gilliam FS, Schwartz MW. Terrestrial plant ecology. Menlo Park, Calif, USA: Benjamin/Cummings, 1999.

Dosskey [12] place the annual cost of soil degradation as high as US$170 million for Ghana, with similar expensive losses in other African countries (**fig. 2**). Cost-benefit analysis of soil conservation at the global level, although uncertain, also suggests that control measures make economic sense [13]. The United Nations estimates the total amount of direct on-site income foregone as a result of desertification (a form of land degradation) in arid regions at US$42.3 billion per year, whereas estimates of the direct annual cost of all preventive and rehabilitational measures range between US$10 billion and US$22.4 billion [14, 15].

The Millennium Villages Project in Africa

A primary aim of the Millennium Villages Project of the Earth Institute at Columbia University (http://www.earth.columbia.edu/mvp) is to meet the Millennium Development Goals (MDGs) (**table 1**) via integrated multisectoral interventions in health and nutrition, agriculture, water, education, access to transport, and environmental sustainability in hunger and poverty hot spots in Africa. The Millennium Villages Project is guided by the recommendations of the UN Millennium Project; it is time-bound to the year 2015 and cost-bound to $110 per person per year, with $70 coming from donor funding, $30 from national and local governments, and $10 from the communities and individuals. The Millennium Villages Project is implemented in 12 sites that cover a very diverse group of agroecological zones and farming systems in Africa (**fig. 3**). The populations of these Millennium Villages are currently caught in the poverty trap that negatively impacts human and environmental health. In each of these sites, the conditions of human health, agricultural production, and environmental degradation will be assessed and monitored before and after multisectoral interventions. The main features of the Millennium Villages Project are community empowerment and leadership; cost-sharing among the partners, including villagers; working with governments at national and local levels; and use of proven, science-based interventions combined with local knowledge, conditions, and priorities. A critical component of the Millennium Village approach is to have existing or newly formed community committees in the different component/sector areas of intervention provide the initial assessments of where interventions are required. Thus, community committees are active in the areas of health and nutrition, agriculture, education, water, energy, and economic planning, and these are integrated within the oversight of a coordinating executive committee.

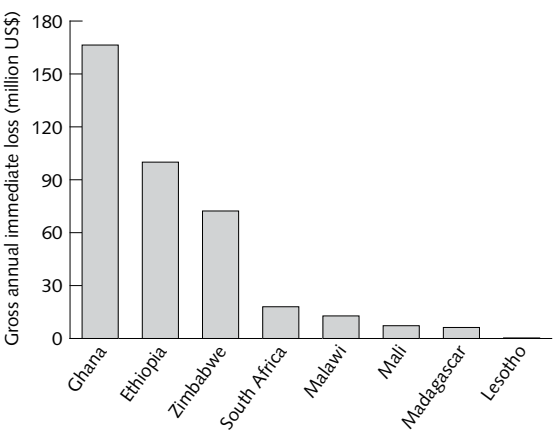

FIG. 2. Nutrient depletion costs of soil degradation in several sub-Saharan countries. Source: Ballard and Dosskey [12].

Very important is not only the intersection of multiple disciplines to form a multisectoral approach, but also the meeting of bottom-up and top-down approaches. All village interventions are community-driven (bottom-up) but are fully supported by national governments and international institutions (top-down) that provide access to resources such as road graders, medicines, fertilizers, and information in the form of local health and agricultural extension agents. This simultaneous multisectoral intervention utilizes the basic tenets of econutrition that nutrition, agriculture, and environmental management and care will bring hundreds and thousands of villages out of poverty, free them from hunger, and enhance human health and individual and national productivity.

Sauri Millennium Village: Initial conditions

The Sauri Sublocation in Siaya District, Nyanza Province, near Lake Victoria in Kenya was the first Millennium Village. It consists of 10 villages in an area of 8 km^2, with a population of 5,200 in 975 households. The area is characterized by hunger periods that occur for 3 to 7 months annually. Sixty-four percent of the population lives in conditions below the poverty line (per capita income less than US$1 per day). An estimated 20% or more of the adult population is infected with HIV; malaria is a constant burden; and at initiation of the project there was no health clinic or electricity, and water came from unprotected springs and waterways.

The Sauri Millennium Village was initiated in late

TABLE 1. The Millennium Development Goals in summary

Eradicate extreme poverty and hunger
Achieve universal primary education
Promote gender equality and empower women
Reduce child mortality
Improve maternal health
Combat HIV/AIDS, malaria, and other diseases
Ensure environmental sustainability
Develop a global partnership for development

Source: [17]

2004 with a baseline assessment to establish current status to measure progress toward the MDGs. These assessments included data gathering and surveys on demographics, socioeconomic status, education and gender, agriculture and environment, water and sanitation, energy sources, community infrastructure, and, importantly, health and nutrition. Blood surveys and anthropometric measurements have been performed for complete blood count analysis, determination of malarial parasitemia, and anthropometrics.

In the Siaya District where Sauri is located, life expectancy at birth is 37 years for males and 43 years for females, stunting is very common, under-5 infant/child mortality is estimated at 170 per 1,000, and maternal mortality is estimated at 8 per 1,000. Data from blood surveys indicated that about 75% of Sauri children under the age of five are anemic (hemoglobin concentration ≤ 11 g/dL). Malarial parasitemia is found in about 43% of the whole population and anemia in about 50%, with 35% of women between the ages of 15 and 49 years having hemoglobin levels less than 11 g/dL.

Preliminary analyses of the baseline data from Sauri in the area of health and nutrition reveal heavy disease burdens in terms of malaria, tuberculosis, and HIV infection, as well as respiratory and diarrheal diseases in children and high levels of both macro- and micronutrient malnutrition. None or very few antimalarial bed nets were available, and food was generally cooked indoors over fires without ventilation for smoke. No fortified foods except for salt were available. Women did not receive any supplements or nutritional advice before or during pregnancy except for vitamin A, which was given to them after delivery under the Ministry of Health vitamin A program. School meals, which were very poor in micronutrients, were available only for students in grades 7 and 8 in only one of the three primary schools in Sauri. The staple foods of Sauri, maize and beans, are low in vitamin A. There was little access to medical care and medicines and few facilities for delivering them.

Sauri Millennium Village: Interventions

In the past 20 months, the villagers have constructed a health clinic, malarial bed nets have been made available to the entire population, transportation to

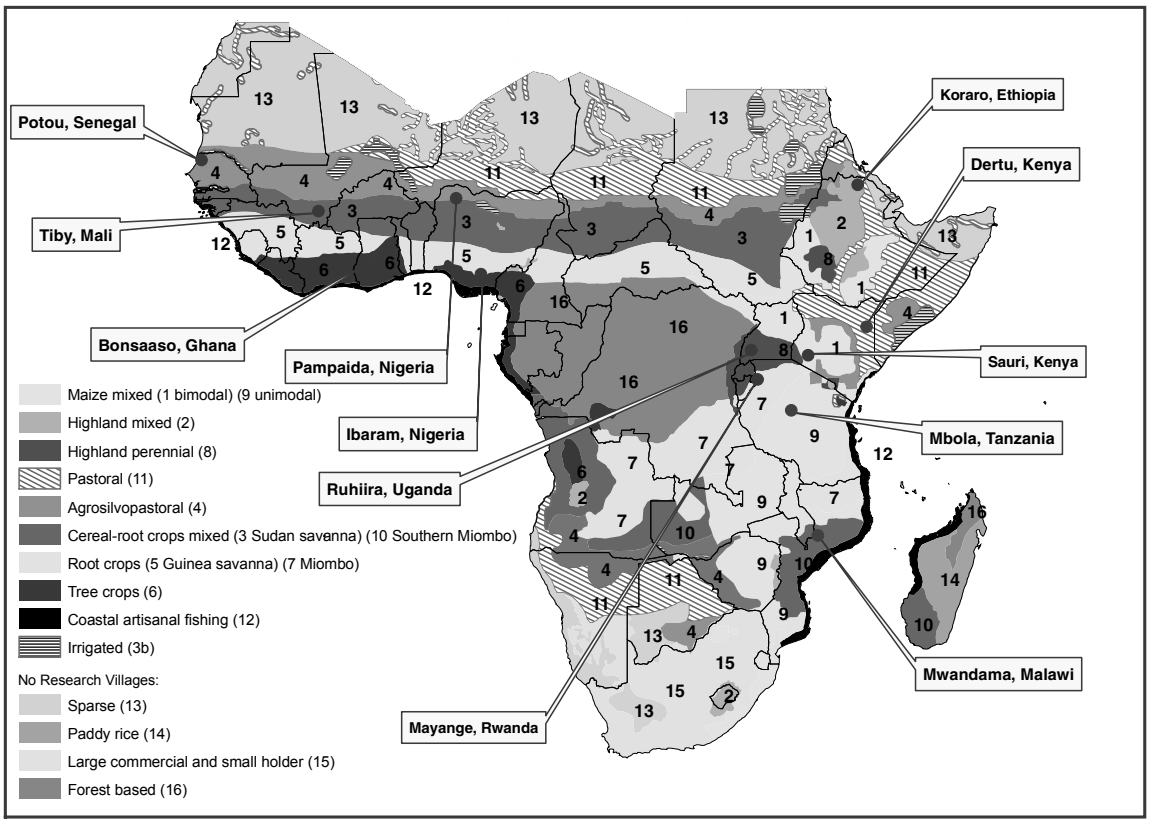

FIG. 3. Locations of the Millennium Villages. Sauri, Kenya, and Koraro, Ethiopia, started in 2004 and 2005, respectively, whereas the remaining villages are starting in 2006–2007. The project aims to have one village and then village clusters in each of Africa's agroecoregions, with the exception of the rice paddy systems of Madagascar and the forest-based systems of the Congo Basin. Adapted from Dixon et al. [16].

emergency services has been made available, and community health-care worker teams have been trained in primary health-care delivery and nutrition. Voluntary counseling and testing for HIV as well as ARV (antiretroviral) treatment is available nearby. The project currently collaborates with the three community schools to implement a more balanced meal program. In exchange for hybrid seeds and nitrogen fertilizers, farmers donate 10% of their harvest to a very much expanded school-meal program. Current plans are under way for integrating diversified local crops into the school-meal program to provide two-thirds of most of the micronutrients, one-third of the calories, and half of the protein needed on a daily basis for children in all grades of primary school. For example, adding guava or sweet potatoes, two locally grown crops, to the school-meal program can eliminate vitamin A deficiencies. This school-meal intervention would not have been possible without the agricultural interventions that boost productivity (see below), which in turn are dependent on a healthy and functioning environment.

At the initiation of the project, there was a high prevalence of degraded soils resulting from years of nutrient depletion that occurred because farmers could not afford fertilizers, with soil carbon levels one-third of those in unmanaged forest soils. Maize yields in Sauri were between 0.75 and 1.60 tons per hectare (compared with 8 tons per hectare in the US Midwest), which translated to 82 kg of maize per person per year, a deficit of 18 kg per year for a child and 32 kg per year for an adult. In addition, the community suffered from a lack of extension agents, unstable market prices, and low labor productivity. Hunger was widespread, with underlying caloric and nutritional deficiencies. Agricultural interventions to boost productivity included distribution of fertilizers and planting of nitrogen-fixing trees and shrubs as low-cost sources of fertilizer. Farmers were able to increase the amount of maize produced from 1.98 tons per hectare in village trial plots to 4.9 tons per hectare with the addition of nitrogen and phosphorus fertilizers. The area under maize and bean cultivation has increased from 229 to 327 hectares. As a result of the increased production per unit area and the increase in the area under cultivation, total maize production increased by about 3.5 times over that in the previous year.

The need for agrodiversity

Whereas in developed countries nutritional diversity can be maintained by a visit to the grocery store, in Sauri, where 60% of the population survives on less than $1 a day, maintaining agrodiversity in the landscape is critical to both human and ecosystem health. As shown in **figure 4**, the major staples of diets used worldwide are very poor in micronutrients. Using rice as an example of a staple food, **figure 5** shows how addition of diverse foods to the diet easily meets major micronutrient needs [18]. As nutritionally complemen-

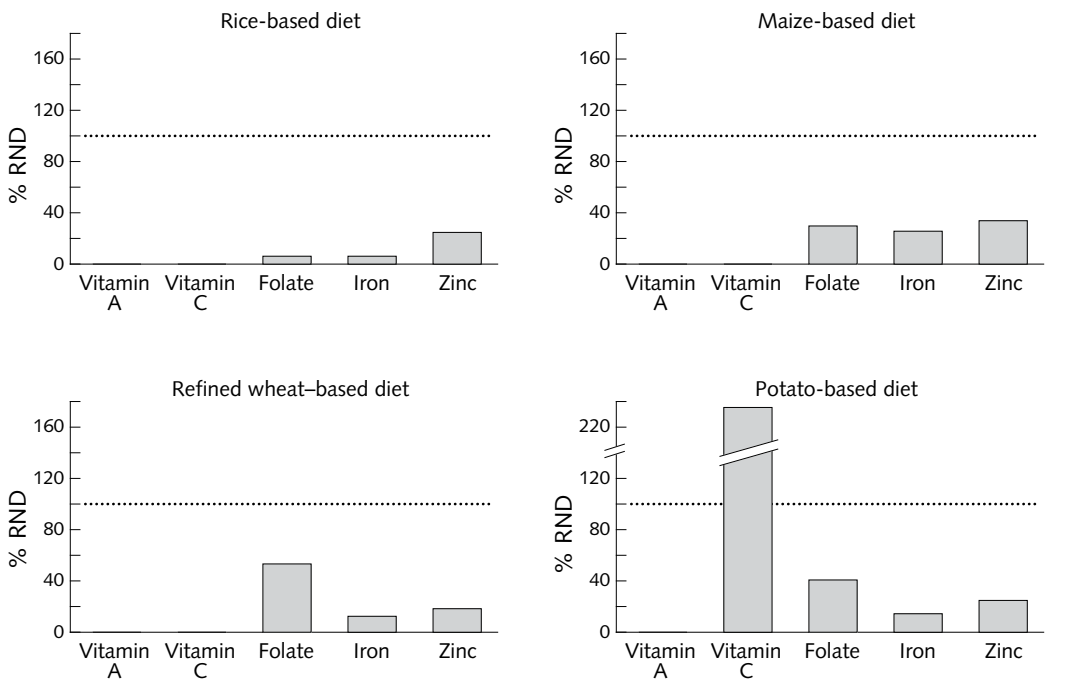

FIG. 4. The insufficiency of common staple foods to meet critical micronutrient needs, expressed as percentages of required nutrient density (RND). Adapted from Uauy-Dagach and Hertrampf [18]

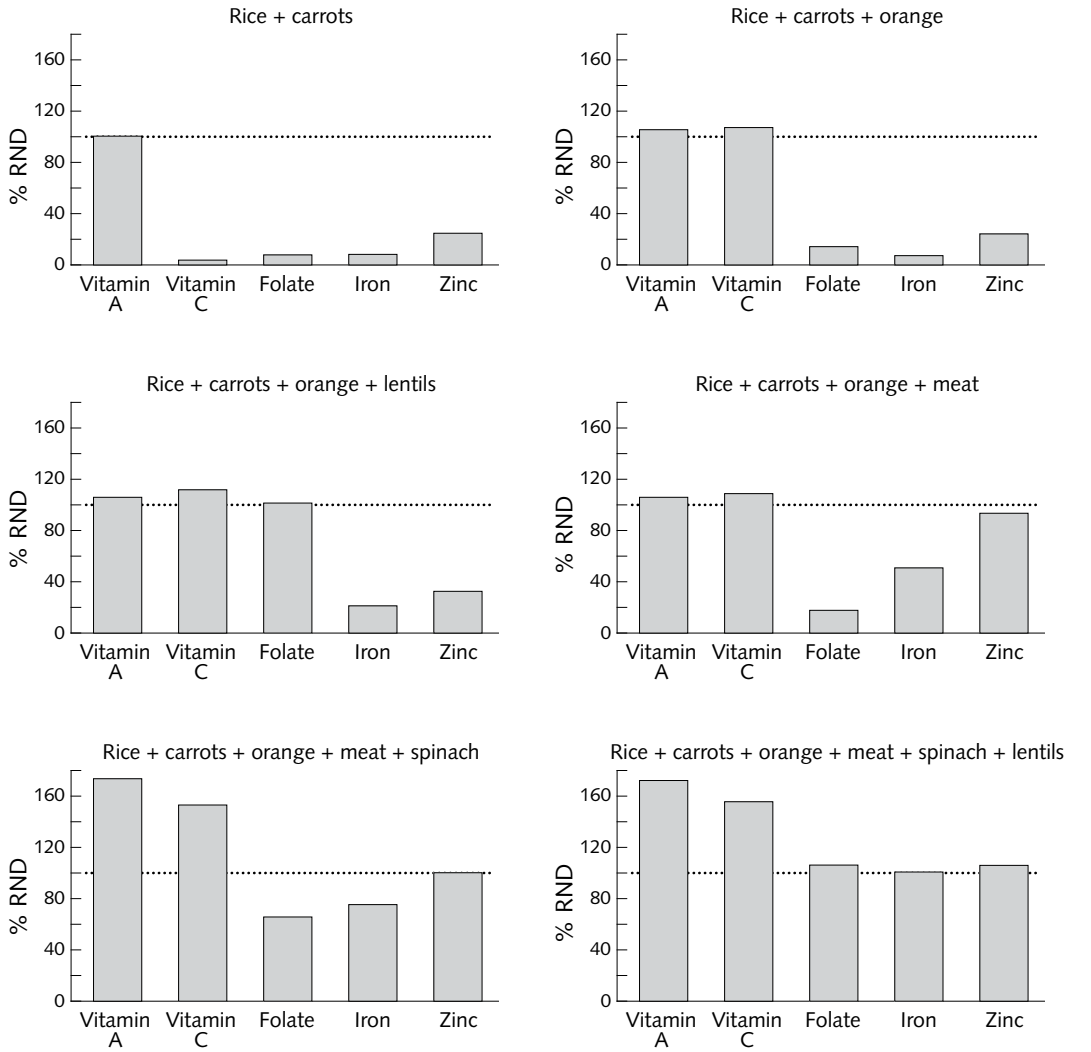

FIG. 5. The effect on micronutrient adequacy of sequentially adding small amounts of nutrient-dense foods, with rice as an example of a staple food. Dietary adequacy is expressed as percentage of required nutrient density (RND). Adapted from Uauy-Dagach and Hertrampf [18]

tary crops are added to the diet, human nutritional needs are slowly met. Crops can be specifically selected and promoted to meet the specific nutritional needs of the Millennium Villages. However, just as nutritionists recognize the unique nutritional function of each food type for maintaining human nutrition, agronomists and agroecologists understand the ecological niches and functions of each species. Maintaining high agrobiodiversity alone is insufficient to meet human nutritional needs; rather, maintaining high functional diversity is critical. Just as the human body requires a diverse diet for maximal functioning, ecosystems depend on functional diversity. For example, soybeans serve to increase soil nitrogen levels and provide protein, rice planted in wetland areas improves water quality, and the incorporation of fish into rice paddies provides an excellent source of nutrition while simultaneously controlling larvae of mosquitoes that carry malaria. Perennial tree crops such as oranges or guava provide fuel wood, can reduce soil erosion, and provide critical habitat to pollinators that are essential to the production of many foods such as tomato or squash.

The integrated approach of the Millennium Villages Project advocates a landscape-scale approach to meet human needs for food, fuel, and energy and ecological needs such as landscape connectivity, soil conservation, pollination and pest control, and water quality [19]. Increasing crop diversity also increases food security through what ecologists call the insurance hypothesis. Increasing crop diversity across the landscape ensures that even during drought or excessively wet years, at least one or more crops will be available for cultivation and consumption.

Interventions in Sauri have been initiated for water

storage and elevation and treatment of water at the source of community streams, along with collection and storage of roof water. There have been improvements in latrines, and fertilizer trees are being made available to simultaneously improve soil fertility, provide fuel wood, and decrease time spent collecting fuel wood by women and children. These interventions, when combined with the introduction of improved cooking stoves and ventilation in community homes, will lead to improved health, decreased workloads, and less environmental degradation. Major efforts are being made in environmental rehabilitation by biological, physical, and chemical approaches, such as reforestation with high-value multipurpose trees. Terraces are being introduced throughout the sublocation to slow the movement of water across agricultural fields and stop the loss of soil. Nitrogen-fixing trees have been planted throughout the community. The environmental committee has established 11 tree nurseries and plans to plant trees along roadsides, on degraded soils, and in spring watersheds to improve water quality. These interventions are aimed at achieving multiple benefits, including provision of a readily available source of fuel wood, protection of water quality in springs, replenishment of nutrients in soils, and maintenance of ecological connectivity throughout the landscape.

Benefits of the multisectoral, econutrition approach

It is not only the villagers that benefit from multisectoral interventions, but science as well. For example, a basic tenet of ecology has been understanding the relationship between biodiversity and ecosystem functioning. In turn, this depends upon knowing the effect of individual species on ecosystem processes such as productivity, water cycling, and soil fertility. However, measurement of individual species traits is often time-consuming and difficult, which limits most biodiversity studies to single, easily measured functions such as productivity. This is equivalent to a nutritionist's considering the effect of food on only a single human function, such as growth. In contrast, there is abundant information on the nutritional value of agricultural species, which is permitting ecologists in the Millennium Villages Project to gain new insights on the relationship between agrobiodiversity and multiple components of human nutrition, one of the most important functions ecosystems provide. Ecologists tend to overlook this function, since its relationship to conservation and natural areas is indirect at best. However, new ecological models based on nutritional data are demonstrating that the significance of biodiversity increases with the number of ecosystem functions of importance to human well-being. Multisectoral research and modeling fill in the "black boxes" that individual disciplines typically take for granted.

In conclusion, econutrition, the relationship between environment, agriculture, and human nutrition, is but one example of how interdisciplinary approaches not only are critical to alleviating extreme poverty through cost-effective programs, but also are fundamental to increasing basic scientific understanding. Applied and theoretical research, as well as human health and agricultural productivity, gains when we take the opportunity to apply our respective disciplines to cross-sectoral, thematically linked interventions.

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International Union of Nutrition Sciences/International Nutrition Foundation (IUNS/INF) prize winner lecture

Good governance for nutrition in the Philippines: Elements, experiences, and lessons learned

Florentino S. Solon

Abstract

Malnutrition is a multifactorial problem that needs a multisectoral solution. This article reviews the role of good governance in nutrition programs, citing the Philippines as an example. In the Philippines, these efforts are reflected in the partnership between the public and private sectors in the establishment of the country's capability in research, policy-making, and program implementation. The establishment of the different public institutions engaged in research and policy-making is discussed, highlighting the role of political will through legislation. The evolving tasks of the nutrition program are discussed by citing the tasks in two eras. In the 1970s, the challenges were limited national nutrition data, manpower, tools, and health infrastructure. The public and private institutions were able to respond by legislating national nutrition surveys and dedicated nutrition workers in each village. The challenges in the current era are improved implementation of health programs, given the devolution of health services, and the gathering of an evidence base to further strengthen and refine the strategies of supplementation, fortification, breastfeeding, and food security. In responding to these challenges, multisectoral solutions and collaboration are critical in providing an evidence base to formulate policy. The role of the private sector, with the Nutrition Center of the Philippines used as an example, is that of a supportive and collaborative partner in good governance. Finally, the lessons learned from the past decades of implementing a national nutrition program, given changes in political and economic circumstances, are summarized.

Key words: Food fortification, governance, legislation, malnutrition, micronutrient malnutrition, nutrition, Philippines

Introduction

Malnutrition goes beyond a mere head count of malnourished children and women. The incidence of malnutrition is generally attributed to a variety of social and economic factors adversely bearing on the human condition. It is such a multifaceted problem that to confine its solutions to setting up "intervention schemes" (preventive and curative measures) for the affected group would be, as it were, just scratching the surface. Coping with malnutrition means getting to the roots of the social and economic conditions that bring it about. It means shaping national policy and planning a deep and comprehensive long-term program to meet nutrition needs. This allows other circumstances of deprivation to be addressed that implicate, in turn, a host of other factors in the socioeconomic system.

The multiplicity of factors in nutrition program work evidently requires a corresponding multidisciplinary and multisectoral approach. This requires a unifying element in the form of strong leadership at various levels of operation to achieve results. On the whole, it is believed that a national nutrition program cannot make much headway without a political will that draws much of its strength from the active support of the highest national leadership. The interplay of developmental elements would be too complex to fuse into a viable program without top-level good governance, which should be replicated at the local level.

Governance is the process of decision-making and implementation. Good governance allows participation by both men and women, respects the rule of law,

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and enforces full protection of human rights. Equity, transparency, and responsiveness to all stakeholders are required in good governance. Good governance mediates to reach broad consensus. Effectiveness, efficiency, and accountability are key requirements of good governance [1].

Structure of the Philippine government

The 1987 Constitution returned the Philippines to a presidential system with a bicameral legislative body and an independent judiciary. The national government has three branches: the executive, the legislative, and the judiciary. The local government units (LGUs) have a three-tier structure (**table 1**). The province is the largest LGU. The municipalities and the cities are in the same tier, but the cities have a larger share of internal revenue allotment. The municipalities are always components of the province; however some cities may be independent of the province. The *barangay* or village is the smallest local administrative unit, with at least 2,000 inhabitants. Thus, cities and municipalities all have *barangays* administratively subordinate to them. The country's 76 million inhabitants are distributed in more than 40,000 villages [2]. Each LGU is headed by a democratically elected official and has an elected legislative body that enacts ordinances and resolutions and appropriates funds for managing the LGU affairs.

The Local Government Code of 1991 (Republic Act 7160) transferred the responsibility for health services (among other things) to the LGUs [3]. At the same time, the LGUs were given the power to raise local revenues, to borrow, and to determine types of expenditures. The devolution of health services, like a double-edged sword, offered opportunities for improved allocation of resources and local decision-making but also initially suffered from logistical difficulties [4]. It is against this backdrop that the current national nutrition program operates.

History

How did food and nutrition planning in the Philippines evolve? The current national program for nutrition is a product of several key forces. The first was the establishment of a systematic assessment of the nutritional problems in the communities. The second was the establishment of a policy-making body to direct and coordinate the efforts of the different agencies and sectors. The third was the partnership between the public and the private sectors which is now increasingly seen as a valid model for pushing the research and program agenda in the field of nutrition and tropical diseases. The fourth was the health and political infrastructure through which programs are translated into action. Selected events and key legislation are summarized in **table 2**, showing the development of institutions, human resources, and policies in nutrition.

TABLE 1. Government structure in the Philippines

LGU	LCE	No. of LGUs
Province	Governor	79
City	Mayor	114
Municipality	Mayor	1,496
Village	*Barangay* captain	41,945

LGU, Local Government Unit; LCE, Local Chief Executive
Source: National Statistics Office [2].

Food and Nutrition Research Institute

In the first half of the 20th century, there were no national nutrition surveys or national nutrition planning. In 1947, the Philippine Institute of Nutrition (PIN) was created to be the clearinghouse for nutrition data under the Office of the President. The PIN eventually became the Food and Nutrition Research Institute (FNRI), which was established as the principal government research institute for food and nutrition.

National Nutrition Council

In 1971, the Nutrition Food and Agricultural Council under the Department of Agriculture was created and tasked to coordinate all nutrition and food activities of both the government and the private sector [5]. The Nutrition Act of the Philippines in 1974 was a milestone in the history of Philippine nutrition [6]. This law made nutrition a priority concern of the government and mandated that the nutrition program be implemented by all agencies concerned in nutrition in an integrated fashion. The law also created the National Nutrition Council (NNC), the highest policy-making and coordinating body for nutrition. The NNC has a governing board composed of 10 of the President's cabinet members and 3 private-sector representatives appointed by the President. Until recently, the chairman of the governing board has always been the Secretary of the Department of Agriculture. The chairmanship has been transferred to the Secretary of Health by a presidential executive order.

The NNC formulates policies and strategies; coordinates the planning, monitoring, and evaluation of the nutrition program; and facilitates the release of funds, as well as requests for grants and loans by governmental and nongovernmental organizations. The NNC secretariat is headed by an Executive Director who supervises the 17 regional offices operated by a Regional Nutrition Program Coordinator who conducts advocacy and coordinates the monitoring and evaluation of

TABLE 2. Summary of selected legislation related to Philippine nutrition*

Public- and private-sector institutions			
Year	Area	Law	Remarks
1947	Creation of the Philippine Association of Nutrition (PAN)		The PAN was critical in the formation of the PIN, which eventually became the FNRI
1947	Creation of the Philippine Institute of Nutrition (PIN)	Executive Order No. 94	
1958	Reorganization of the PIN into the Food and Nutrition Research Center (FNRC)	RA 2058	
1959	Creation of the Nutrition Foundation of the Philippines (NFP)		The NFP is a private organization conceived to help the government in promoting better nutrition for Filipinos
1975	Reorganization of the FNRC into the Food and Nutrition Research Institute (FNRI)		
1971	Nutrition Food and Agricultural Council (NFAC)	Executive Order No. 285	The NFAC was the forerunner of the NNC. The NNC was established as a policy-making body through the Nutrition Act of the Philippines (PD 491)
1974	National Nutrition Council (NNC)	Nutrition Act of the Philippines (PD No. 491)	
1974	Nutrition Center of the Philippines (NCP)		The NCP is a private, nonstock, nonprofit organization that is engaged in research and program development in nutrition
Manpower			
Year	Area	Law	Remarks
1977	Creation of *Barangay* Nutrition Scholars (BNS)	PD No. 1569	The BNS was a pilot project by the NCP in cooperation with the Government. This was later institutionalized through this law
1995	Incentives for *Barangay* Health Workers	RA 7883	This law recognized the value of village health workers by giving incentives for volunteerism
Nutrition policy			
Year	Area	Law	Remarks
1986	Breastfeeding	EO 51	The issuance of executive orders and enactment of legislation related to nutrition are a result of the multisectoral consultation and coordination that was made possible by the Nutrition Act of the Philippines
1992	Breastfeeding	RA 7600	
1995	Salt iodization	RA 8172	
2000	Food fortification	RA 8976	

* Executive orders emanate from the executive branch of the government unit. Republic Acts are laws enacted by the Congress of the Republic of the Philippines. Presidential Decrees were used during the period when the Philippines was under martial law.

the plans and programs in their respective LGUs. Letter of Instruction 441 was issued by the President in 1976 to designate lead agencies for the delivery of particular nutrition interventions.

Nutrition Center of the Philippines

The Nutrition Center of the Philippines (NCP) was established in the same year as the NNC. The NCP is a private, nonprofit organization whose mandate is to mobilize nongovernmental resources, conduct research, and develop nutrition program models in support of the Philippine nutrition plan and program. The NCP is not funded by the government. Income-generating subsidiary corporations help sustain the NCP. The Philippine Nutri-Foods Corporation (PNFC) develops and sells micronutrient-fortified complementary and supplementary foods and nutrition-related items used by government agencies and nongovernmental organizations in food assistance programs. The NCP Publishing Corporation (NCPPC) develops nutrition information and educational materials designed for the different target audiences of the NNC national nutrition education program.

The relationship of the NNC and other government agencies with the NCP can be considered a model of public–private partnership. The contribution of the NCP as a private partner of the NNC can be seen in the different aspects of the design and development of the national and local government nutrition programs and projects, and in its research that supports

the formulation of legislation for nutrition. The NCP's nonbureaucratic form of governance has been advantageous in relating its function to all levels of the government agencies, international organizations, and academic institutions.

In 1977, the NCP was selected as an associated institution of the United Nations University (UNU). Together, the UNU and the NCP have provided advanced training in community-based planning and management of nutrition programs to UNU fellows chosen from developing countries of Asia, Africa, and Latin America.

Nutrition surveys

At the beginning of the national nutrition effort, information on the national nutrition situation was not available. There were no national nutrition surveys to guide policy makers. The FNRI conducted the first National Nutrition Survey in 1978. The FNRI is the research and nutrition assessment arm of the Department of Science and Technology, a member of the NNC. The national nutrition surveys have been conducted every 5 years since 1978. Thus, there have been six national nutrition surveys conducted from 1978 to 2003. The FNRI has also conducted regional nutrition surveys of anthropometry, dietary, and biochemical indicators that cover one region per year. The survey results are analyzed, interpreted, and fed back to the NNC governing board and, more importantly, to the LGUs and the public through multimedia. The findings of the national survey serve as a guide for planners and programmers to identify the regions and even the provinces and populations that are most at risk for protein–energy and micronutrient malnutrition. Likewise, these series of regional surveys, together with the findings of the FNRI's special studies and of research of other sectors, were the basis of the NNC's first national nutrition policy and the Philippine Nutrition Program (PNP). In the early 1970s, the PNP identified protein–energy malnutrition, vitamin A deficiency, anemia, and iodine-deficiency disorders as the main nutrition problems to be addressed.

Operation *Timbang*

In the 1970s, there was clearly a need to start a nationwide movement to create awareness of the nutrition problem and the accompanying solutions at the village level. The government and nongovernmental organizations organized a mass weighing of preschool children in every village of the country. Operation *Timbang* (which means "weighing") aimed to determine the weights of preschool children so that immediate nutrition assistance could be given to the underweight children and nutrition changes recorded on a growth-monitoring chart [7]. In the process, Operation *Timbang* awakened the community's awareness of nutritional problems, and participation in solving these problems was enhanced.

Early on, one practical problem with Operation *Timbang* was the availability of a standard weighing scale in the *barangay*. This problem encouraged innovation. The NCP developed a bar-type weighing scale ("barscale"). The Department of Health (DOH) validated and field-tested the barscale and recommended it for field use together with the Salter scale [8]. Operation *Timbang* as institutionalized by the NNC is now conducted once a year.

Operation *Timbang* is a nationwide *barangay*-driven assessment effort, and the results give a profile of nutritional status at the village level. In the *barangay*, families with underweight children are identified and targeted for delivery of vital nutrition services. At the policy level, these data allow the planners to rank the region, provinces, municipalities, and *barangays* according to the prevalence of underweight among preschool children.

Local nutrition organizations

The strategy of the national nutrition program is the establishment of an active organizational structure at all levels of operation. Whereas the NNC is responsible for national-level planning, there are regional, provincial, municipal, and *barangay* nutrition committees composed of individuals from government and the private sector. These committees are headed by the highest political leaders in the respective LGUs. On the premise that the solution to malnutrition should begin in the home, the organizational effort starts with the policy maker closest to the family, the *barangay* captain. The *barangay* captain is vested with two vital powers, executive and legislative. These can be used at the village level to facilitate the implementation of the nutrition program.

The *barangay* has been pinpointed as the focal point of planning and implementation of the nutrition program. The municipal mayors and the nutrition committees, assisted by a designated municipal nutrition action officer, plan, coordinate, and manage the nutrition programs of the respective *barangay*. Both the municipality and the *barangay* have a share of internal revenue allotment as a source of income, as well as social development funds of which a certain percentage may be used for social projects, including health and nutrition projects. The municipal and *barangay* local chief executives (LCEs) and their respective legislative bodies have discretion on the amount to be allocated for such purposes in their areas.

As mentioned earlier, the devolution of services

to the local administrative units provided for by the Local Government Code gives greater autonomy and responsibility to the LGUs. It is therefore important to strengthen local nutrition planning and programming under the leadership of the local government executives.

Manpower for nutrition and health

To mobilize the people of the community to accept and practice good nutrition, a properly selected and well-trained cadre of volunteers is necessary. The NCP conceptualized, developed, and piloted a program that trained *barangay*-based nutrition workers called *barangay* nutrition scholars (BNS) to be the nutrition movers in the *barangay*. The BNS are carefully selected volunteers from the *barangay* who undergo intensive training in the delivery of practical nutrition services: monitoring the growth of preschool children, communication of simple nutrition messages to parents, particularly pregnant and lactating women, and timely delivery of food and pharmaceutical supplements to targeted women and children. After the NCP piloted the BNS project with the LGUs, the NNC scaled up the BNS project to be implemented nationwide through a law (see **table 2**) providing a BNS in every *barangay* [9]. About 22,000 BNS are now serving the country.

The BNS is further strengthened by another volunteer, the *barangay* health worker (BHW). These volunteers render primary health-care services, including nutrition, in a cluster of 20 to 30 households in every *barangay*. As an incentive to volunteerism, a law enacted in 1995 [10] grants the BHWs hazard and subsistence allowances, educational programs, civil service eligibility, and preferential access to loans (see **table 2**). These benefits go to more than 200,000 BHWs in the country.

Nutrition situation

For many years, the country has addressed the same problem of malnutrition in its various forms. In 2003, the sixth National Nutrition Survey found that 3.5 million preschool children were underweight, a prevalence of 27%. The prevalence had been reduced only by less than one percentage point per year for the previous 10 years. Thirty percent of preschool-aged children were stunted. Among children 6 to 10 years of age, the prevalence of underweight was 27% and the prevalence of stunting was 36% [11].

Anemia and vitamin A deficiency continue to afflict a substantial proportion of vulnerable Filipino children and women. The trends are alarming. Among children, between one-third (preschoolers and schoolchildren) and two-thirds (infants) are anemic. Four out of 10 pregnant and lactating women are anemic. Vitamin A deficiency, a key contributor to mortality and morbidity in children, continues to be present in roughly 4 out of 10 children, despite twice-yearly vitamin A supplementation. These rates have not declined substantially over the decades, and in one age group (infants), they have slowly increased. However, iodine status showed encouraging progress over 10 years, with a significant reduction of iodine deficiency among schoolchildren according to urinary iodine levels. In addition, the country continues to undergo serious political and economic changes and is burdened by debt and natural disasters that adversely affect efforts to maintain the nutritional status of the population.

Medium-term Philippine Plan of Action for Nutrition

On the basis of the results of the FNRI National Nutrition Survey, the NNC Secretariat, together with the Technical Committee, formulated the Medium-Term Philippine Plan of Action for Nutrition (MTPPAN), the country's framework to improve the quality of life of the population through better nutrition and improved health [12]. The Plan serves as a reference for national program planners, policy makers, private and nongovernmental organizations, and funding agencies. The devolved government agencies provide the LGUs with operational guidelines of the detailed essentials of the program components. The MTPPAN 2005–10 program strategies are focused as follows: infants and children 1 to 3 years old, adolescents, and pregnant and lactating women are priority targets; areas with high rates of malnutrition and poverty are priority targets for intensive nutrition services; food-based interventions focus not only on production and consumption of nutrient-rich and fortified food, but also on exclusive breastfeeding and use of nutrient-dense complementary foods to ensure food security; and the nutrition program is complemented by other development interventions.

The strategies are applied in the development and implementation of the core programs: home, school, and community food production; food fortification; food assistance; micronutrient supplementation; and nutrition education.

Food-based intervention

The MTPPAN places food production measures as one of the priority programs within the provisions of the Agriculture and Fisheries Modernization Act of the Department of Agriculture, in which alleviation of poverty and social equity, food security, rational use of resources, sustainable development, and empowerment of people are the important principles. The

NCP introduced a food production project called Food Always in the Home (FAITH) for people to grow organic, chemical-free vegetables and fruits and raise small animals at home. The project particularly stressed community and home food security and targeted families with underweight preschoolers. A self-instructional manual for FAITH has been developed to be used in the *barangay*. Although the MTPPAN has adopted FAITH as one of the food-based strategies, the NCP will investigate the efficacy and effectiveness of the home food production intervention in improving the nutritional status of the household's vulnerable members [13].

The government's policy of promoting fortification of processed food with vitamin A and iron has achieved good compliance from manufacturers. This policy was preceded by the NCP's first randomized, controlled trial that demonstrated the efficacy of vitamin A–fortified margarine [14, 15]. This study provided evidence that vitamin A fortification of an oil-based consumer product was effective. The results were then readily translated into action by using them as advocacy tools for promoting the benefits of fortified food products.

To promote fortified food products, the margarine was awarded a stamp of recognition from the DOH and the words "accepted by the DOH" were placed on the label. From this initial stamp evolved the *Sangkap Pinoy* (meaning Filipino or indigenous ingredients) seal, a mark of recognition from the government of a properly fortified, high-quality food product. Today, 71 processed food products are fortified with vitamin A [16], although only the margarine has had an efficacy trial and only about 6 of these fortified products are frequently used [17].

The good response by manufacturers of processed food to the food fortification policy encouraged the government to promote the policy further with the ultimate aim of fortifying staple foods: rice with iron, wheat flour with iron and vitamin A, cooking oil with vitamin A, and sugar with vitamin A.

The food industry identified two main issues. First, the technology of food fortification should fit easily into the production process. Second, the micronutrients added to the staple food should be stable, cause no organoleptic changes, and be efficacious.

The government, through the FNRI, developed and transferred the technology of fortification of cooking oil [18] and sugar with vitamin A to the food industry. The FNRI developed the technology of fortification of rice with iron. An efficacy trial showed that consumption of iron-fortified rice improved iron status [19]. Biofortified rice has also been shown to be effective [20].

In 1995, the NCP conducted a wheat flour fortification study that showed substantial retention of vitamin A in flour and *pandesal* (wheat bun) without any organoleptic changes. Two years later, the efficacy of vitamin A–fortified *pandesal* was assessed by a randomized, controlled trial among schoolchildren in four rural schools. After a 6-month intervention that provided each child with 60 g of either fortified or nonfortified *pandesal* daily, the number of children with inadequate liver stores of vitamin A was reduced by 50% [21]. Since the government policy is to fortify wheat flour with vitamin A and iron, the NCP proceeded to conduct a stability study on wheat flour fortified with iron alone or in combination with vitamin A. The study showed that both vitamin A and iron were stable in wheat flour and its products (unpublished data).

The results of the rice and wheat flour fortification studies were used as a basis for the Philippine Food Fortification Law (see **table 2**), which was fully implemented in November 2004 [22]. The President declared November 7 Food Fortification Day to be observed nationwide every year.

Food assistance

The government food assistance program has a long history of implementing various supplementary feeding schemes to rescue and rehabilitate malnourished children. This provides windows of opportunity for innovative food formulations of calorie-dense and nutrient-adequate standard recipes for supplementary and complementary feeding of infants and preschool-aged children. In addition, the feeding activity (including assistance during disasters) serves as an entry point for conducting health and nutrition education and other complementary activities.

The MTPPAN gives priority to providing identified underweight young children aged 6 to 24 months with supplementary food containing one-third of the recommended energy and nutrient intake (RENI) for a period of 120 days. Given the limited budget of the government, it has become necessary to prioritize populations for interventions. School-aged children in grades 1 and 2, with priority given to the underweight, are likewise given supplementary food (breakfast or morning snack) in school to alleviate their hunger, accelerate their school performance, and improve their nutritional status. Pregnant women are supposed to be screened to identify those who are wasted or stunted or have a history of giving birth to a low-birthweight infant, and these women are given priority for supplementary food assistance.

For three decades, the NCP, through its subsidiary PNFC, has formulated and processed high-calorie, high-protein, and vitamin A–fortified foods as supplements to family foods and as complementary foods for breastfed children. The Nutri-Pak is a product consisting of rice blended with a legume and skimmed milk and containing a separate 15-g packet of edible oil fortified with vitamin A. The Nutri-Pak was awarded the *Sangkap Pinoy* seal by the DOH. There are six varieties of Nutri-Pak, which are widely used by national and

local governmental and nongovernmental organizations for community or institutional feeding. Other PNFC products include biscuits and noodles made from wheat flour fortified with vitamin A and iron, and powdered, vitamin A–fortified whole milk flavored with cocoa [23].

The government considers breastfeeding and complementary feeding a food-based intervention. To promote and protect breastfeeding, the government has adopted a national code of marketing for breastmilk substitutes and supplements [24] and enacted legislation to promote rooming-in and breastfeeding [25] (see **table 2**). The campaign also focuses on promoting exclusive breastfeeding for the first 6 months, followed by the introduction of family foods or fortified complementary foods that provide the nutrients children need while they continue breastfeeding.

Micronutrient supplementation

The problem of clinical and subclinical vitamin A deficiency in the Philippines has long been emphasized in studies in Cebu [26–29]. Supplementation of children under 6 years of age with high-dose vitamin A capsules (200,000 IU) has been in place in the country for 13 years. The increase in vitamin A deficiency reported in the national surveys of 1993, 1998, and 2003 has compelled the government to investigate the reason that this alarming trend continues despite nationwide biannual supplementation (with an average coverage of 80%). An early study in the Philippines that compared supplementation every 6 months, fortification, and home food production found no improvement in the vitamin A status of supplemented preschool-aged children, and it recommended that children should receive supplementation every 3 to 4 months [28]. The International Vitamin A Consultative Group (IVACG) recommends an interval of 4 to 6 months [30].

The FNRI used the results of the 1998 National Nutrition Survey to study the effect of the vitamin A supplementation program on subclinical vitamin A deficiency among preschool children [31]. The study found that the reduction in deficiency by high-dose vitamin A capsules was limited and did not persist for 6 months, particularly in areas of high prevalence, and that in less severely affected areas the effect of the capsules was greater among stunted than among nonstunted children. The authors suggested that in areas with a high prevalence of vitamin A deficiency, a three-times-yearly schedule is warranted, and that in areas of low prevalence, stunted children detected by screening should receive vitamin A capsules more frequently. We must bear in mind that the greater justification for vitamin A supplementation rests on the effect of community-based supplementation on child mortality rather than on biochemical indicators alone.

The MTPPAN, on the basis of the FNRI study, is recommending a three-times-yearly schedule of vitamin A supplementation while the FNRI conducts a controlled field study of this schedule. The vitamin A supplementation program targets lactating women for the high-dose capsule every 6 months, whereas pregnant women are supplemented with 10,000 IU tablets daily or twice weekly from the fourth month of pregnancy until delivery [32]. The NCP position is that targeting pregnant mothers for vitamin A supplementation is not necessary.

The iron supplementation policy and program are targeted to infants, preschool and school-aged children, adolescents, and pregnant and lactating women. The NCP conducted a government-funded study to determine the effectiveness of weekly iron supplementation among rural children without deworming in areas of light helminth burden [33]. The DOH, assisted by the WHO Regional Office for the Western Pacific, conducted a study of iron–folic acid supplementation of Filipino women of reproductive age and showed that iron status was significantly improved in both pregnant and nonpregnant women who took the supplement weekly for at least 6 weeks [34]. Another study, funded by the DOH, was conducted by the NCP to determine the effectiveness of a redesigned iron supplementation delivery system in reducing the prevalence of anemia in pregnant women. The system was effective in reducing anemia and increasing the number of prenatal visits and the proportion of pregnant women with adequate prenatal visits [35]. It also led to an increase in the proportion of pregnant women taking iron supplements and an almost twofold increase in the mean percent compliance of the pregnant women with iron supplementation.

A manual for the village health workers which documented the features of the redesigned iron supplementation delivery system for pregnant women and the steps of how it was implemented was developed by the NCP. The NCP, together with the DOH, will field test the manual before scaling it up for nationwide application.

The current government universal salt iodization program started with UNICEF, and the DOH assisted a nationwide survey of salt producers conducted by the NCP. Information was collected on salt production and consumption, methods and facilities for production and marketing, price, transport, and storage facilities. The results of the survey served as the main basis for the salt iodization law [36] (see **table 2**). Most salt is sold in the community exposed in open heaps. Some salt is repackaged in low-density polyethylene. The Bureau of Food and Drugs (BFAD) under the DOH prohibits the sale of iodized salt in an open heap. The BFAD and the NCP conducted a study to compare the stability of iodized salt sold in open heaps with that of salt sold repackaged in plastic. The iodine levels of salt sold by both methods were within allowable

levels after one month of exposure under simulated market conditions [37]. The BFAD is now studying a modification of the salt iodization standard and reviewing the guidelines for implementation of the law. The National Nutrition Survey found that the percentage of households using iodized salt rose from 25% in 1998 to 56% in 2003. Iodine status also improved remarkably, with a reduction in the prevalence of iodine deficiency among schoolchildren from 35% in 1998 to 11% in 2003 according to measurements of urinary iodine excretion levels.

The DOH, the NNC, and nongovernmental organizations jointly developed a micronutrient supplementation guide for the use of LGUs, particularly the health units, containing information about the targets, pharmaceutical preparation, form, and doses of the supplements as well as the procedures for procurement of the supplements.

Nutrition education

The NNC policy requires member agencies to actively pursue nutrition information, education, and communication (IEC) campaigns directed to priority groups. The NCP introduced innovative measures needed to reach remote areas and widely scattered targets. A few examples of public–private partnership are cited below.

The teacher–child–parent (TCP) approach, designed by NCP and institutionalized by the Department of Education, integrates health and nutrition in the elementary school curriculum [38]. Messages are conveyed between the school and the home by the child. A key feature of the TCP approach is a set of manuals each of which covers a specific program area in the curriculum. The manuals contain the nutrition and health messages that are presented as lesson plans for the schoolteacher. With its impressive track record, TCP was chosen as one of the innovative components of Educational Technology for Basic Education of the Education for All Program of the Philippines for the decade 1991–2000.

Several materials were developed by the NCPPC for the use of health workers at various levels. Highly illustrated manuals explaining the important aspects of community health and nutrition were developed for village-based health and nutrition workers and translated into six major Philippine languages. A reference manual for physicians covers topics on assessment and management of nutritional disorders. A food prescription pad containing illustrated instructions with recommended amounts for preschoolers, pregnant and lactating mothers serves as an innovative tool for dietary advice [39].

The Mass Media Nutrition Education Study (1975) in Iloilo Province demonstrated the power of radio to educate and change behavior. Conducted by the NNC and Manoff International, the study involved the use of 60-second messages broadcast by commercial radio three to four times daily for one year**.** The study found an increase in the number of mothers who adopted the new behavior of enriching porridge with oil, fish, and vegetables [40].

The NCP Nutri-Bus Project was a mobile and comprehensive system organized in 1978 to provide support to the *barangay* health and nutrition workers. Shown on the bus were videotapes on health and nutrition using communication techniques to change or modify the behavior of targeted vulnerable groups, especially pregnant and lactating women and their preschool and school-aged children. The vehicle contained Nutri-Pak supplies, seeds and seedlings of vegetables for distribution to target populations, and food prescription pads.

A series of evaluative studies on the Nutri-Bus project was carried out from 1979 to 1981 in the province of Leyte to measure changes in knowledge, attitudes, and nutritional status of program beneficiaries. The results of the 1979 study showed that mothers in villages exposed to more video showings were 55% more likely to describe complete meals, 73% more likely to name Nutri-Pak (the high-calorie, high-protein food supplement) as a good snack, and 71% more likely to give specific descriptions of Nutri-Pak. The 1981 study showed that the levels of knowledge among mothers in 1979 were being maintained. Between 1979 and 1981, the level of moderate and severe malnutrition among children decreased by 17 percent and the level of normal nutrition and mild malnutrition increased by 12 percent.

A very important development in the country's health and nutrition education effort is the active involvement of the broadcasting and advertising industries. An example is the cooperative venture between the NCP and the J. Walter Thompson Company (Philippines), one of the top advertising companies in the country.

The venture involved the production of 15 30-second television spots on food values and sources for a nutrition awareness campaign. Aired over Philippine television in 1984, the project immediately became one of the most popular public service campaigns to hit the television screen. Entitled *"Pagkaing tama sa abot kayang halaga"* (roughly translated as "right food, within reach"), the project was conceptualized by J. Walter Thompson with technical input from the NCP.

In 1984, the NCP–J. Walter Thompson nutrition campaign won the Catholic Mass Media Award for Best Public Service TV Advertisement, and in 1985 it won the award for the Best Public Service Radio and TV Advertisement (after the television spots had been produced as radio plugs and aired nationwide). At the

Asian Advertising Congress in Bangkok, Thailand, the campaign won the silver medal of the Max Lewis Memorial Challenge Award [41].

In 2000, the Nutritional Guidelines for Filipinos was prepared by a technical group of government and non-government organizations [42]. This revision of the 1990 Dietary Guidelines for Filipinos contains 10 messages to promote good health through proper nutrition.

Monitoring and evaluation

The MTPPAN provides that the NNC conduct annual plan and program assessment called the Monitoring and Evaluation of Local Level Plan Implementation (MELLPI) to determine the efficacy and effectiveness of the nutrition plans and programs implemented at the local level. In assessing the progress of the programs, the MELLPI identifies their strengths and weaknesses to help guide any remedial actions to be taken.

The NNC is also the focal agency in the country for the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS), whose function is to collate, assemble and analyze vital data for measuring and monitoring food insecurity and vulnerability and to disseminate information about which areas are food-insecure or at risk for food insecurity.

Lessons learned

The following lessons have been learned from experience with nutrition in the Philippines:

The Nutrition Act of the Philippines and other laws were the key to the sustainability of the nutrition programs for three decades.

Public–private partnership, involving international and UN agencies and industries, adds great value to all aspects of the nutrition program.

Transparency in national nutrition survey results triggered actions from executive and legislative bodies, nongovernmental organizations, international cooperators, and the media.

Over the years, local leadership may change, as well as nutrition workers. But good nutrition plans and programs driven by the community and the family remain.

The results of well-designed local studies that show evidence of either efficacy or effectiveness of an intervention program being proposed or carried out provide scientific bases for decision makers to support the sustainability of the program.

Barangay health and nutrition workers, with adequate capacity-building, can effectively deliver health and nutrition services in the community.

Good governance in nutrition can withstand threats and constraints from changes in national leadership and political and socioeconomic upheavals.

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Short communication

Nutritional status of adult Santal men in Keonjhar District, Orissa, India

Kaushik Bose, Falguni Chakraborty, Kapil Mitra, and Samiran Bisai

Abstract

Background. *Although tribal people constitute a sizable proportion of India's population, there is little information on their anthropometric and nutrition status.*

Objective. *The present study was undertaken to study the anthropometric characteristics of adult Santal males. It also attempted to evaluate their nutritional status based on body-mass index (BMI) and mid-upper-arm circumference (MUAC).*

Methods. *A cross-sectional study was conducted of adult (aged > 18 years) male Santals, a tribal population of Keonjhar District, Orissa, India. A total of 332 Santals from five villages (Gourshinga, Kashibera, Kumunia, Majhisahi, and Sonatangri) in the Anandapur Region of Keonjhar District were included in the study. These villages are located approximately 150 km from Bhubaneswar, the provincial capital of Orissa. Anthropometric measurements, including height, weight, and MUAC, were performed according to a standard protocol. Nutritional status was evaluated on the basis of internationally accepted cutoff points of BMI and MUAC.*

Results. *The mean height, weight, MUAC, and BMI of the men were 162.5 cm, 51.7 kg, 23.7 cm, and 19.6 kg/m^2, respectively. The prevalence of undernutrition (chronic energy deficiency [CED]) based on BMI was 26.2%; 3.3%, 3.9%, and 19.0% had grades III, II, and I CED, respectively. According to MUAC cutoff points, the prevalence of undernutrition was 33.7%.*

Conclusions. *The level of undernutrition among adult Santal males was high. Appropriate nutritional intervention programs should be implemented immediately.*

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Key words: Anthropometry, India, nutritional status, Santals, tribes

Introduction

Only recently has there been an attempt to assess malnutrition in adults living in the Third World. This seems surprising, given the widespread concern about world hunger and whether food supplies are adequate for the populations of different regions of a country or for those living in refugee camps [1]. India remains one of the poorest countries in the world, with a population of over one billion and a fertility rate well above replacement level [2]. Moreover, improvements in the nutritional status of the population during the last two to three decades have not been impressive [3]. More than half of the world's undernourished people live in India [4].

Tribal groups are among the most underprivileged people in India. They comprise about 8% of the population of India, which probably has the largest number of tribal communities of any country in the world [5]. The Santals are the third largest tribal group in Orissa, with a total population of 629,782 in the districts of Mayurbhanj, Baleswar, and Keonjhar [6]. Their mother tongue is Santali, an Austro-Asiatic language. They traditionally prefer to live in hilly forest clearings, where their main occupation is settled agriculture, followed by gathering of forest produce.

The use of anthropometry as an indicator of nutritional and health status of adults is now well established [7]. Body-mass index (BMI; the weight in kilograms divided by the square of the height in meters) is an indicator of overall adiposity, and measures of circumferences are indicators of regional adiposity [8]. Although adult nutritional status can be evaluated in many ways, the BMI is the most widely used because it is inexpensive, noninvasive and suitable for large-scale surveys [1, 9–11]. BMI is generally considered a good indicator of not only the nutritional status but also the socioeconomic condition of a population, especially

adult populations in developing countries [10, 12–14]. A BMI of less than 18.5 is widely used as a practical measure of chronic energy deficiency (CED), i.e., a steady condition of underweight in which an individual is in energy balance irrespective of a loss in body weight or body energy stores [15]. Such a steady condition of underweight is likely to be associated with morbidity or other physiological and functional impairments [7, 12, 16].

Another anthropometric measure that can be used to evaluate adult nutritional status is the mid-upper-arm circumference (MUAC). It has been shown that the MUAC is particularly effective for the determination of malnutrition among adults in developing countries [1]. MUAC is a simpler measure than BMI, requiring a minimum of equipment, and in practice has now been found to predict morbidity and mortality as accurately as deficits in weight [17].

There are few data on the anthropometric and nutritional status of the tribal populations of India [18]. The objectives of the present study were to report the anthropometric characteristics and to evaluate the nutritional status, based on BMI and MUAC, of adult Santal men of Keonjhar District, Orissa. To the best of our knowledge, this is the first report on the anthropometric and nutritional profile of adult Santal males from Orissa.

Materials and methods

This study was conducted in collaboration with the Associated Social Service Agency (ASSA), a non-governmental organization based at Sailongchhak, Anandapur, Keonjhar District, Orissa. Ethical approval and prior permission was obtained from the Vidyasagar University ethics committee and local community leaders, respectively, before commencement of the study. Informed verbal consent was also obtained from each participant. Information on ethnicity, age, occupation, and educational status was obtained from all subjects with the aid of a questionnaire.

The data were collected from five villages inhabited predominantly by Santals in the Anandapur Region of Keonjhar District of Orissa: Gourshinga, Kashibera, Kumunia, Majhisahi, and Sonatangri. These villages are located approximately 150 km from Bhubaneswar, the provincial capital of Orissa.

All adult (> 18 years) males in the five villages were contacted. The response (participation) rate was 74%, and the sample size was 332. Almost all of the subjects were illiterate. They were predominantly settled cultivators or very low-paid manual laborers. Thus, they belonged to the low socioeconomic class.

Anthropometric measurements were made by a trained investigator (K.M.) using standard techniques [9]. Height and weight were recorded to the nearest 0.1 cm and 0.5 kg, respectively. MUAC was measured with a tape to the nearest 0.1 cm. Technical errors of measurement were computed and were found to be within acceptable limits [19]. BMI was computed from the following standard equation: BMI = weight (kg)/height (m^2)

Nutritional status was evaluated according to internationally accepted World Health Organization (WHO) BMI guidelines [7]. The following cutoff points were used:

Status	BMI
CED grade	
III	< 16.0
II	16.0–16.9
I	17.0–18.4
Normal	18.5–24.9
Overweight	≥ 25.0

We used the WHO classification [7] of the public health problem of low BMI, which is based on adult populations worldwide. This classification categorizes prevalence of CED according to the percentage of the population with BMI less than 18.5:

» Low (5%–9%): warning sign, monitoring required
» Medium (10%–19%): poor situation
» High (20%–39%): serious situation
» Very high (≥ 40%): critical situation

Nutritional status was also evaluated on the basis of the internationally recommended MUAC cutoff point of less than 23.0 cm for undernutrition [1]. All statistical analyses were performed with the Epi Info statistical package.

Results and discussion

The mean age of the men was 34.7 ± 13.1 years (range, 19 to 75 years). The mean values of height, weight, MUAC, and BMI are presented in **table 1.**

Table 2 presents the frequency of undernutrition, based on BMI as well as MUAC, among the men. On the basis of BMI, the frequency of CED (BMI < 18.5) was 26.2%; 3.3%, 3.9%, and 19.0% had grades III, II, and I CED, respectively. The frequency of undernutrition according to MUAC was 33.7%. An odds ratio

TABLE 1. Anthropometric characteristics of adult Santal males of Keonjhar District, Orissa, India

Characteristic	Mean	SD	SEM
Height (cm)	162.5	5.8	0.32
Weight (kg)	51.7	5.6	0.31
MUAC (cm)	23.7	2.1	0.12
BMI (kg/m^2)	19.6	1.8	0.09

SD, standard deviation; SEM, standard error of the mean; MUAC, mid-upper-arm circumference; BMI, body-mass index

TABLE 2. Nutritional status of adult Santal males of Keonjhar District, Orissa, India based on BMI and MUAC

Status	Prevalence (%)
BMI-based CED	
Grade III	3.3
Grade II	3.9
Grade I	19.0
Total CED	26.2
MUAC-based undernutrition	33.7

BMI, body-mass index; MUAC, mid-upper-arm circumference; CED, chronic energy deficiency

(OR) analysis of low MUAC (MUAC < 23.0) with low BMI (BMI < 18.5) was performed, and the OR was found to be highly significant (OR = 3.25; 95% CI = 1.89 to 5.62).

Although there are limitations of BMI in terms of distribution of stature over different age groups, it is still the most widely used measure of nutritional status among adults worldwide [7]. Since the majority of the subjects in the present study were below 50 years of age, individuals were not classified into different age groups. Several recent studies in India [14, 15, 20–23] have utilized BMI to study the nutritional status of tribal populations. Similarly, the use of MUAC cutoff points has been applied worldwide [1], particularly in developing countries.

The results of the present study clearly indicate that the prevalence of undernutrition among adult male Santals was high on the basis of either BMI (26.2%) or MUAC (33.7%). Both of these percentages fall within the high range (20% to 39%) considered by WHO to indicate a serious situation. High rates of undernutrition have also been reported from other tribal populations of India [14, 15, 20–23]. Moreover, the odds ratio of low MUAC with low BMI is highly significant ($p < .001$), which indicates that these measures are well correlated and implies that either of these measures could be used to evaluate nutritional status among Santal men. However, the difference in the prevalence of CED according to the two different measures may have public health implications. The use of MUAC may be preferred, since many individuals who would be classified as having CED on the basis of MUAC may not be classified as having CED when BMI is used as a measure of CED. Thus, the target group for intervention would be reduced if BMI were used. Furthermore, with limited resources and in the absence of skilled personnel, it may be more appropriate to use MUAC for population surveys. Most important from the viewpoint of public health, immediate nutritional intervention programs are needed for this group. The Indian Government should play an active role in reducing the rates of undernutrition among tribal people such as the Santals.

The economic and health burden of high frequencies of adult undernutrition have been well documented [1, 10, 15, 24–25]. The functional and economic significance of a high prevalence of CED has already been established [26]. Therefore, efforts must be made to investigate the consequences of the functional impairments commonly associated with low BMI in this demographic group. It is also essential to ascertain the relationship of the high rate of undernutrition with morbidity and mortality.

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Book reviews

Nevin S. Scrimshaw

Disease control priorities in developing countries. 2nd edition. Edited by Dean T. Jamison, Joel G. Breman, Anthony R. Measham, George Alleyne, Mariam Claeson, David B. Evans, Prabhat Jha, Anne Mills, and Philip Musgrove. World Bank Publications, Washington, D.C., 2006. (ISBN 0-8213-6179-1) 1452 pages, hardcover. US$125.

The book is unique in its comprehensive approach. It is the second edition of a massive compendium, first published in 1993 with multinational support and designed to provide information on the cost-effectiveness of health interventions in a wide variety of settings. It is intended to influence the redesign of programs and the reallocation of resources to reduce morbidity and mortality, particularly among the poor. This revision comes at a time when every developing region is facing a transition in epidemiologic profile from one with high mortality due to nutritional and infectious diseases to one in which lower fertility and changing lifestyles have added a burden of obesity, cardiovascular disease, cancer, diabetes, and tobacco addiction.

The book gives guidance on how better to spend funds for health and how to adapt interventions to the capacity of the countries' health systems, and it points the way to "proactive supply-driven provision of a set of highly cost-effective interventions on a large scale that bridge clinics and homes." This book is unique in its scope and its truly multidisciplinary approach. Its theme is that the poor cannot afford anything but the most efficient methods for organizing and implementing health care. It seeks "to inspire all who seek the highly complex but attainable goal of universal good health for all members of the global community."

There are 346 contributors to this volume. It is too extensive and diverse to summarize, but every significant public health topic is included. For each, consideration is given to affordability, scaling up, economic benefits, weaknesses of existing programs, suggestions for improving their effectiveness, research needs, and much more. Nutritional topics are well represented and thoroughly covered. Every health and nutrition worker concerned with policy and program implementation should have access to and familiarity with this compendium.

Reaching the poor with health, nutrition, and population services: what works, what doesn't, and why. Edited by Abdo S. Yazbeck, Davidson R. Gwatkin, and Adam Wagstaff. World Bank Publications, Washington, D.C., 2005. (ISBN 0-8213-5961-4) 376 pages, softcover. US$30.

This paperback presents 11 case studies of how well or how poorly health, nutrition, and population programs have performed in reaching disadvantaged groups. The studies were commissioned by the Reaching the Poor Program, a collaboration between the Bill and Melinda Gates Foundation, the World Bank, and the governments of Sweden and the Netherlands, "in an effort to find better ways of ensuring that health, nutrition, and population programs benefit the poor." It is gradually being recognized by health-sector policy makers and the international development community that spending on health does not necessarily mean reaching and serving poor people. These case studies are an effort to find out what works and why in order to design interventions that will be more effective.

The first three chapters explain the empirical evaluation techniques used, describe the types of programs covered, and provide an overview of the findings and policy implications. The studies reviewed were selected from 56 study reports. The indicators available from these studies included 27 outcome indicators concerned with child illness and mortality, fertility, nutritional status, female circumcision, and sexually transmitted diseases. The 46 outcome indicators covered child immunization, treatment of children's illnesses (fever, acute respiratory infections, diarrhea), antenatal and delivery care (antenatal care visits and content), delivery attendance, contraceptive surveys (prevalence, public sector, private sector), treatment of adult illnesses (genital discharge, sores), HIV/AIDS,

household indicators including hygienic practices, bednet use, breastfeeding, micronutrient consumption, tobacco and alcohol use, sexual practices, domestic violence, education, exposure to mass media, knowledge of and attitudes to HIV-AIDS, and status of women (household decision-making, freedom of movement, other decision-making), and status of orphans.

What did the Reaching the Poor studies find? The emphasis was on demonstrating the research method rather than on guidance applicable to only a few countries and topics. However, the overall conclusion was that "much better distributional performance on the part of health, nutrition and populations programs is possible." The three studies of nutrition programs are all from Latin America. In Argentina, the incidence changes resulting from public health and nutrition programs in the five years of the study favored the "nonpoor." In Brazil, health coverage was lower among the poor for the two universal programs studied, immunization and antenatal care. The recommendations included an increase in the number of and access to service units, improved access to referral services, increased monitoring and evaluation, and feedback of the results. In Peru, the main problem was reaching the poor with nutrition programs, but "further research is definitely needed before any action is taken."

These studies provide insights into how well large-scale nutrition and health programs reach the poor, but improving their targeting will not be easy. A general conclusion is that better approaches to service delivery are needed if the poor are to be reached effectively. Some health workers will be interested in applying the methodology, and many will benefit from exploring this wealth of program data for application to their own national nutrition and other health programs.

Lipid metabolism and health. Edited by Robert J. Moffatt and Bryant A. Stamford. Taylor & Francis Group/CRC Press, New York, 2005. (ISBN 0-8493-2680-X) 376 pages, hardcover. US$119.95.

This volume provides an in-depth overview of the historical evolution of serum lipids and lipoproteins from a curiosity to an accepted major risk factor for cardiovascular disease and the formulation of clinical guidelines. The individual chapters are well and authoritatively written, with exceptionally good documentation. Most provide important guidance for clinical and public health.

The chapters have direct clinical and preventive relevance, clarity, and practical advice. Particularly useful are those on Cardiovascular Risk Assessment; Lipid and Lipoprotein Metabolism; The Vascular Biology of Atherosclerosis; Exercise Training and Endothelial Function; Essential Laboratory Methods for Blood Lipid and Lipoprotein Analysis; Metabolic Syndrome; Obesity, Lipoproteins and Exercise; Pharmacological Treatments of Lipid Abnormalities; New insights on the Role of Lipids and Lipoproteins in Cardiovascular Disease; Physical Activity, Exercise, Blood Lipids and Lipoproteins; Acute Changes in Lipids and Lipoprotein-lipids Induced by Exercise; Smoking, Heart Disease, and Lipoprotein Metabolism; and Lipid and Lipoprotein Concentrations in Americans: Ethnicity and Age.

Every chapter is of interest and use to all concerned with human nutrition and the relation of dietary lipids to health. This book is highly recommended to anyone needing directly applicable up-to-date consensus information on the risk factors for cardiovascular disease and on how to formulate public policy, health education, and clinical preventive management to reduce them.

Two books on carbohydrates and polysaccharides in foods

Carbohydrates are polysaccharides that have always been the world's bulk source of food for humans. The development of new polysaccharide derivatives for food use continues steadily. There has been a continuous increase in the understanding of the molecular structure and conformation of polysaccharides. Advances in sophisticated, computer-based analytical methods and bioengineering technology have led to more detailed knowledge of biosynthetic pathways and enzyme systems and to higher and more functional yields. The influence of structure on functional properties and on polysaccharide interactions with other food components is now better understood. More is also now known about the nutritional values and disease-preventing value of polysaccharides of various kinds. Two books just published in second editions address this subject in overlapping but different ways. Both books will be useful primarily to food technologists, but the first reviewed devotes 2 of its 11 chapters to the nutritional characteristics of nondigestible carbohydrates and starch.

Carbohydrates in food. 2nd edition. Edited by Ann-Charlotte Eliasson. Taylor & Francis Group/CRC Press, New York, 2006. (ISBN 0-8247-5942-7) 560 pages, hardcover.

The second edition of *Carbohydrates in Foods* provides thorough and authoritative coverage of the chemical analysis, structure, functional properties, and nutritional relevance of monosaccharides, disaccharides, and polysaccharides used in food. It is a comprehensive source of the latest data on the analytical, physico-

chemical, and nutritional properties of carbohydrates. It evaluates the advantages and disadvantages of using various analytical methods for carbohydrates in food. It covers the important functional aspects of carbohydrates and the relevant nutritional topics relating to carbohydrates in food. It also illustrates how carbohydrates can be used in the development of products with health benefits for the public.

The book's strengths include revised and expanded reference lists, strong coverage of the significance of carbohydrates in the diet, and new and updated information in every chapter. The 11 chapters are individually authored and include all aspects of mono- and disaccharides, cell-wall polysaccharides, gums and hydrocolloids, nondigestible carbohydrates, and starch. Where appropriate, the health and nutritional aspects are discussed. Both food scientists and nutritionists will find this book a convenient, comprehensive, and authoritative source of information on carbohydrates in food.

Food polysaccharides and their applications. 2nd edition. Edited by Alistair M. Stephen, Glyn O. Phillips, and Peter A. Williams. Taylor & Francis Group/CRC, New York, 2006. (ISBN 0-8247-5922-2) 752 pages, hardcover. US$189.95.

Ten years after its original publication, this second edition of *Food Polysaccharides and Their Applications* has been revised and expanded to provide a much updated and even more comprehensive coverage of food polysaccharides.

Although there is much overlap with Ann-Charlotte Eliasson's *Carbohydrates in Foods*, there is more specialized coverage. For example, in addition to chapters on polysaccharides, starches, and gums, it has chapters on agars, carrageenans, alginates, inulin, pectins, chitosans, and dietary fiber. A short chapter on genetic engineering and food crops describes progress in breeding plants for more desirable polysaccharide properties, with amylase-free potato starch as an example. The final chapter focuses on the detection and determination of polysaccharides in foods.

This new edition covers the changes that are currently taking place in the knowledge and development of new polysaccharides and related derivatives. Each chapter is written by different authors, but they are uniform in quality, with negligible overlap, and are well referenced.

In memoriam

Rainer Gross, an outstanding international public health leader of his generation died on September 30, 2006, after a long, courageous fight against cancer while undergoing painful experimental treatments. At the time, he was holding a position of great importance to global nutrition as Chief of the Nutrition Section of UNICEF and continued to lead it almost until his final weeks. This issue of the *Food and Nutrition Bulletin* includes a very personal tribute from Noel Solomons, one his international collaborators and close friends.

The editors of the *Bulletin* would like to supplement the remembrance by Dr. Solomons with a few additional details of Rainer Gross' life and contributions. Dr. Gross was born September 28, 1945, in Germany. He obtained doctorates in both nutrition (1974) and agriculture (1982) at Justas Liebig University in Giessen, Germany, and in 1971 he began a career of over 30 years with the German International Aid Agency, commonly known as GTZ. His service with GTZ included long-term assignments in Peru, Brazil, and Indonesia.

After working with the Institute of Nutrition and Ministry of Health in Lima from 1972–82, Dr. Gross spent two years at GTZ headquarters as specialist advisor for nutrition. This was followed by a four-year period promoting the postgraduate program in human nutrition of the Federal University of Rio de Janeiro. After another two years of service at GTZ headquarters he served from 1989–1998 as advisor to the Southeast Asian Ministers of Education Organization (SEAMEO) Training Program in Community Nutrition of the University of Indonesia. He then returned to Brazil for a year as a visiting professor at the Faculty of Nutrition of the School of Public Health in São Paulo. In 2000, he began an assignment as long-term advisor to the graduate public nutrition program at the National Agricultural University La Molina, Lima. In addition to these assignments, he served as a consultant to programs in Armenia, Bangladesh, Ethiopia, South Africa, Tajikistan, Vietnam, and to nutrition programs of the International Atomic Energy Agency (IAEA).

Dr. Gross began serving as Chief of the Nutrition Section of UNICEF in April 2002. In this new capacity, he promoted an increasing emphasis on nutrition and on understanding the factors affecting nutrition and how nutrition affects other aspects of the health, development, and care of children and women. He strove to expand and accelerate nutrition-related programs and projects at the country level, to increase nutrition monitoring and evaluation, and to better adapt nutrition interventions to country-specific needs. For as long as possible he continued to fight to improve nutrition competency across the organization in advocacy, technical, managerial, and networking knowledge and skills. Before his untimely death he had the satisfaction of seeing many of his ideas incorporated into the new UNICEF Joint Health and Nutrition Strategy for 2006–2015, which was approved by the Executive Board in January 2006.

Dr. Gross' research and scholarly work and publication record is remarkable, especially given his active work in consulting and advisory services and frequent changes of venue. A reference list, which is not up to date, credits him as the author or editor of 13 books and journal supplements, 32 book chapters, 123 articles in peer-reviewed journals, and 24 other technical articles.

Dr. Gross' work was also recognized by his peers and the countries he helped. He received major awards for his contributions from Peru, Germany, Vietnam, and the Asian Pacific Nutrition Society. Throughout his career, he was strongly supported by his wife, Ulla, both professionally and personally. The above only partially captures the importance of his international contributions and unique personal qualities of initiative, integrity, dedication, compassion, hard work and sacrifices in service to the developing world. His leadership, enthusiasm, developing-country experience, and good judgment will be greatly missed. A great many of us in the international nutrition community will

keenly miss this highly valued colleague and cherished personal friend.

Nevin S. Scrimshaw
Senior Associate Editor

Reflections on the life and legacy of Rainer Gross, 1945–2006

Rainer Gross was a man of meetings, teaching, and family. On Saturday, September 30, 2006, when the arduous and valiant fight to remain with and within his family came to an end, many of Rainer Gross' friends and colleagues were gathered at an international nutrition meeting in Barcelona—the First World Congress of Public Health Nutrition—a meeting where his name had been mentioned often, both in terms of his role at UNICEF and of concern for his failing health.

The man of meetings

Rainer loved the give and take of meetings; many of the landmarks of his life and career came in and around the convocations that the Inernational Union of Nutrition Scientists (IUNS), the United Nations Standing Committee on Nutrition (SCN), the Latin American Nutrition Society (SLAN), the International Vitamin A Consultative Group (IVACG), and the Federation of Asian Nutrition Societies (FANS)—and that Rainer himself—would periodically convene. I had so much in common with Rainer Gross. For one thing, we both began attending the ICN meetings in 1972, when the 9th Congress was hosted by Mexico City. At that time, he and Ulla were based in Peru, performing the field research of their respective doctoral degrees at the University of Giessen. I began attending the ICN meetings at the same time, having gone to Mexico to make the arrangements with professionals from the Institute of Nutrition of Central America and Panama (INCAP) for what would become my fellowship studies in Guatemala. From that date forward, through Kyoto, Rio de Janeiro, San Diego, Brighton, Seoul, Adelaide, Montreal, and Vienna, Rainer kept a perfect attendance record, as did I. Of course, we would not actually meet one another until a year before the Brighton congress.

The first time Rainer Gross and I would ever have a serious conversation was in 1984; we were sitting on the legendary inlaid sidewalk of the Copacabana Beach in Rio de Janeiro. I was in Brazil for orientation to the local faculty and my teaching duties as a visiting lecturer at the Universidade Federal de Rio de Janeiro. Rainer lifted his eyes from the beach walk to the heights; there were the desperate *favelas* on the hillsides behind Copacabana and Ipanema. He commented that international nutrition was consumed by the status of rural populations, but had been ignoring the problems of the urban area. The urban situation, he suggested, was equally important as the rural, and much more complex. That sentiment struck a responsive chord with me, as my experience in Guatemala had reflected the obsession with the "villages," while ignoring the metropolitan populace. In that moment, we forged a gentleman's alliance to raise the profile of urban nutrition. When the 13th International Congress on Nutrition (ICN) came around in August 1985 at Royal Brighton, UK, we received assistance from Prof. John Waterlow to get a small, off-site venue to hold a workshop on urban nutrition. The small classroom was jammed with interested participants from all over the world. Proceedings of that event became a monograph, *Tropical Urban Nutrition*, which Rainer and I edited and published in 1987. This would be the first of 15 publications on urbanization and nutrition that we would produce over the next three decades.

Vienna was the site of the 17th ICN, and in a fateful conversation at the reception at the historic Town Hall, Rainer was asked whether or not he would be interested in applying for the post of heading the Nutrition Unit at UNICEF. Almost 10 months later the offer came in a telephone call from New York to his home in Lima. This move would consolidate the recognition of his extraordinary career of organizational and teaching initiatives, and project him into the heart of the United Nations System, where he would contribute, during all too brief a period, from this final position in New York City. It was poignant and troubling that his illness would keep him from keeping his attendance record perfect through Durban, South Africa, in September 2005, for the 19th ICN. It was really not an ICN without Rainer!

Rainer organized a host of meetings on his own initiative. Many had to do with the IUNS Committee on Urbanization and Nutrition. In more recent years, they would be on the theme of multiple micronutrient supplementation. In 2003, the *Food and Nutrition Bulletin* published a supplement, edited by Rainer and me, which presented the "foodlet" as a viable option to combat the hidden hunger of micronutrient malnutrition. It represented the proceedings of a conclave held in May 2002 in Lima, organized by Rainer. This was the last in a series of five meetings in New York, Rio de Janeiro, Singapore, Cape Town, and finally, Lima; these meetings had seen the birth of the notion of a food-like tablet, the establishment of the UNICEF-funded International Research on Infant Supplementation (IRIS) field trials at four international sites, and finally, the first compiling and sharing of the findings. The leadership and vision was 100% pure and vintage Rainer Gross.

A passion for teaching

Rainer's true vocation was teaching, and he had a passion to deliver education in the most modern and

creative formats. He was an innovator. At one of those many meetings we jointly attended, in this instance a SLAN meeting in Chile in 1988, Rainer conducted a workshop on urban nutrition. To make the event more participatory, he based his approach on the Goal-Oriented Program Planning (ZOPP, for its acronym in German) methodology, which involved the sorting of index cards with ideas from the participants to create a causal hierarchy problem tree, followed by a solutions tree to create an intervention, and finally the indicators for evaluation. It was a brilliant adaptation, giving voice to those too retiring to raise their own voice. The ZOPP methodology became a standard feature of many, many workshops and class exercises that Rainer would organize from 1989 through 1997, while he headed the IUNS Committee on Urbanization and Nutrition.

The innovative spirit became manifest with each of the three community nutrition programs he helped launch as investment projects of the Gesellschaft für Technische Zussamenarbeit (GTZ), first in Rio de Janeiro, then in Jakarta, and finally, in Lima. The first innovation was their modular nature; I had the privilege to teach the introductory module, on nutritional biochemistry, in the masters course at each of these three sites. Rainer's approach was total dedication. His mantras were "learn to read and write in English" and "prepare yourself to be an investigator." Twice per week, the students had "Morning Vitamins," which was a journal club presentation on an English-language original research article. Moreover, no one got his or her masters degree without producing a thesis based on original field research. Those of us involved in these courses got the opportunity to mentor some very talented young individuals, many of whom have subsequently become leaders in nutrition in South America and Southeast Asia.

In addition to his GTZ posts abroad, Rainer was also an adjunct professor at his alma mater, the University of Giessen, and at the University of Bonn. Exchange students from Germany would enrich the student environments of the outpost assignments in Brazil and Indonesia. Moreover, each year, when Rainer and Ulla would take their home-leave "vacations" to Ulla's parents' home near Mainz, the couple would participate in classroom teaching for German nutrition students at the two institutions. It was around the preparation of German exchange students for their thesis studies that the ZOPP methodology made another leap in the innovative hands of Rainer Gross. He developed a process for planning research (rather than interventions) using hierarchical logic of causal relations that he called SHARP (Systematic Holistic Action Research Planning). He published the method in the *Bulletin*, and it became the standard for preparing thesis protocols at Bonn, Giessen, and Jakarta. In fact, this process left the classroom and reached the IUNS committee system. Expressly using the SHARP approach, a group the Committee on Urbanization and Nutrition members gathered in Wageningen, the Netherlands, in 1996 to draft a multicentric research protocol, CRONOS (Cross-Cultural Research on Nutrition in Older Subjects), which would form the basis of thesis projects in Indonesia, Vietnam, the Philippines, and Guatemala. It was published in a supplement to the *Bulletin* in 1997.

A family man

Rainer loved to spend time at home with his family. Over the years, this was not one home, but many. These included a circular, upper-floor apartment in a skyscraper condominium on the Barra de Tijuca waterfront in Rio; a spacious one-story Indonesian-style garden home in Jakarta; a modest, residential house in the Rhine valley village of Alzey; a multilevel manor on the highest prominence of the eastern rim of Lima; and a small apartment on the East Side of New York City.

Rainer was a devoted and adoring husband and father. His wife, Ulla, always had a teaching role in the community nutrition courses around the world, but Rainer was especially supportive of her research interests, which ranged from practices regarding colostrum to the imagery of food intake.

I first got to know the Grosses' daughter and son, along with their beagle, Flecky, when they were in their early school years, living in Brazil. I could communicate with the dog, but since Kerstin and Patrick's home language was German and their street language was Portuguese, my communication was with them was limited during the Brazil years. However, as the Gross children would be educated in the international American schools in various cities, this barrier would correct itself by the Indonesia years, when Kerstin and Patrick were fluent English-speaking teenagers. In Jakarta, we would stay in the Gross family home, and I truly felt part of the clan. Dinners were classic family meals, with exchanges of juvenile inquisitiveness and parental wisdom and experience. The most rewarding times for me, however, were the Sundays, when we could lounge around the backyard pool for a leisurely brunch, swim, and conversation. Research and collaboration were high on the agenda, but also the politics of the nutrition community—and the politics of the world—occupied our ramblings.

Rainer was delighted when his offspring took up projets in his own areas of interest. Kerstin's high-school biology project in Jakarta involved studies on the lupin, a protein-rich Andean legume to which Rainer had taken a fancy during his plant-biology studies in Peru. Meanwhile, Patrick, the budding engineer, helped bring field diagnostic use to a high-tech reflectometer, which had the promise of allowing for the estimation of hemoglobin and hemodynamics simply by applying an electrode to a subject's skin.

The house on the hill of *la Planicia* in Lima was truly a dream home, and the home that Ulla and Rainer dreamed of retiring to. Their children were in graduate school, so the Peruvian home was founded as an empty nest. The Grosses had cultivated close and enduring friends in Lima in the 1970s, and had begun to reconnect during their return with the teaching project at the Agrarian University in the late 1990s. The Limeña residence had elegant gardens and a fabulous panoramic view. It would first be the decision to take the UNICEF post in New York, and then Rainer's illness, that would limit his worthy and long-awaited enjoyment of the Lima manor. Only recently, the Gross family had blossomed with a third generation, as Kerstin and Patrick had both made grandparents of Ulla and Rainer in recent years. He certainly had all too little time to bask in the joys of being a grandfather.

Epilogue

It is fitting that Rainer Gross be remembered in the pages of the *Food and Nutrition Bulletin*, as he helped to fill its pages with important and innovative themes over the years. In my reflections, I think of the many languages in which he communicated his ideas and teaching: German, English, Portuguese, Spanish, and Bahasa Indonesian. I retrace many of the topics he addressed in his life: lupins, anemia, ZOPP, SHARP urban nutrition, weekly iron supplementation, multiple micronutrients, and foodlets. In this reverie, I cannot avoid the term "heroic," in the sense of a legendary figure, slaying so many dragons from a devotion to principle and with an intense sense of passion, with all of the ideas coming from an inner vision and insight. Also heroic, in the sense of personal heroism, that is, a hero as he faced what would be his final test. Rainer fought a staunch fight to survive his disease and remain with his family.

No doubt, his family knows how fortunate and blessed they were to have had Rainer as their husband and father. As for me, there are countries that I never would have visited, studies I never would have undertaken, students I never would have mentored, and papers I never would have written had not it been for the opportunities placed in my path by Rainer Gross. In these reflections, it becomes obvious just how deeply my own life has been touched and my own career enriched by having first sat on the shoreline of Rio and followed Rainer's eyes as he set his gaze to the heights. He was forever looking upward to a newer challenge or a higher standard, and more often than not he—and others around him—would get to a higher plane, following the vision of this marvelous man and dearest of friends.

Noel W. Solomons, MD

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

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

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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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