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c/o Dr. Nevin S. Scrimshaw, Editor
P.O. Box 330
115 Sandwich Notch Rd.
Campton, NH 03223, USA
Tel: (603) 726-4200
Fax: (603) 726-4614
Subscription address:
International Nutrition Foundation
c/o Dr. Irwin Rosenberg
711 Washington St.
Boston, MA 02111, USA
Tel/Fax: (508) 539-4743
E-mail: unucpo@tiac.net

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All correspondence concerning the content of the *Bulletin*, comments, news, and notices should be sent to the editor at the editorial office address given above.

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The *Food and Nutrition Bulletin* is intended to make available policy analyses, state-of-the-art summaries, and original scientific articles relating to multidisciplinary efforts to alleviate the problems of hunger and malnutrition in the developing world. It is not intended for the publication of scientific articles of principal interest only to individuals in a single discipline or within a single country or region. Notices of relevant books and other publications will be published if they are received for review. The *Bulletin* is also a vehicle for notices of forthcoming international meetings that satisfy the above criteria and for summaries of such meetings.

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The Food and Nutrition Bullletin encourages letters to the editor regarding issues dealt with in its contents.

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Possible use of spreads as a FOODlet for improving the diets of infants and young children

André Briend

Key words: diets, infants, children, FOODlet, spreads

Abstract

Spreads are high-viscosity fat products prepared by mixing dried powdered ingredients with a vegetable fat chosen for its viscosity. Spreads are not traditionally used for feeding infants or young children and were initially proposed for feeding severely malnourished children during the recovery phase. The advantages of these products include a high energy and nutrient density, a very good acceptability, and resistance to bacterial contamination. Adapted spreads could be designed to boost the nutritional density of diets of young children from poor communities. Spreads could be mixed with the meals or porridges traditionally given to infants or eaten by themselves as snacks. Formulation of spread products is flexible, and acceptability and efficacy trials are required to optimize their composition and fortification levels and to select the best-adapted ingredients for each setting.

Introduction

Poor children in developing countries receive a diet with little milk and meat products and with a low content of fruits and vegetables. This dietary pattern seems to be related to cost constraints [1]. Diets of these children also have high proportions of cereals and legumes, with large amounts of phytate and other inhibitors of divalent metal absorption [2]. As a result, poor children have a low intake of highly absorbable iron and zinc, and iron and zinc deficiencies are among the most prevalent in poor communities [3, 4]. Other deficiencies associated with a low intake of animal products, fruits, and vegetables, such as deficiencies of riboflavin, retinol, and vitamin B12, are also common [5].

There are several possible approaches to improve complementary feeding in poor communities, but all of them have some major disadvantages [6]. Dietary diversification with inclusion of micronutrient-rich foods in children's diet is often impossible because these foods are expensive. The staple food can be fortified with micronutrients missing in the diet, but fortification levels are usually insufficient for infants with high nutrient needs and low consumption of staple foods. Fortified complementary foods can be prepared by mixing a cereal flour with a high-protein ingredient, either dried skimmed milk or soy flour, but this approach is often too expensive to reach the poor. Micronutrients can be given directly to the child in cheap chewable or self-dissolving tablets, but high compliance levels are difficult to achieve with this approach.

Problems of micronutrient supplementation throughout the life cycle were reviewed at a meeting organized by the Ministry of Health, Brazil, and UNICEF in Rio de Janeiro in November 1999. It was agreed that a new approach was needed to supplement infants and young children aged 6 to 24 months [7]. It was proposed to develop and field test a food-like supplement with a micronutrient content comparable to that of a tablet. The name "foodlet" was coined to describe this approach, which was midway between a tablet and a food supplement. The characteristics of a foodlet, as defined by the Rio meeting, were low production cost, long-term stability of all added micronutrients, easy dosability, and convenience of feeding to a nursing child by the mother. In addition, the product should have a food-like appearance. This approach seems attractive: it could be precisely targeted to vulnerable groups, high compliance levels should be achieved if the selected food supplement is well accepted, and it should be relatively cheap.

Following the Rio meeting, a foodlet was developed and used in a multicenter supplementation trial in

The author is affiliated with the Institut de Recherche pour le Développement and is currently working at the Institut des Sciences et Techniques de la Nutrition et de l'Alimentation, Unité INSERM U 557, in Paris. He is a consultant for Nutriset, a company that produces fortified spreads.

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

infants and young children led by the International Research Group on Infant Supplementation (IRIS) in Peru, Indonesia, Vietnam, and South Africa. Preliminary results of this study, reviewed in a meeting in Lima, Peru, in June 2001 [8], suggest that it has good efficacy, especially for prevention of anemia. The foodlet used during this first study, however, looked more like a tablet than a food, and is best described as a foodLET. Potential advantages of using a spread to develop a FOODlet, i.e., a foodlet that looks more like a food than a tablet, were discussed and are reported here.

Spreads in infant and child feeding: background

Spreads are prepared by mixing dry powdered ingredients (dried milk products, precooked soy flour, sugars, dextrin maltose, minerals, and vitamins) with vegetable fat. The fat component should have a viscosity and a melting point adjusted to make the resulting product easy to store and to swallow. More precisely, it should have a low viscosity at 37°C, the temperature of the mouth.

Spreads are not traditionally used for preparing foods for infants and young children. They were initially proposed to feed severely malnourished children in relief operations. These children, according to the World Health Organization (WHO) recommendations, should be fed a low-protein, low-energy, milk-based diet for a few days while associated complications are being treated. Then, during the rehabilitation phase, i.e., for two to three weeks, a high-protein and high-energy milk diet, the WHO F100 diet, highly fortified with vitamins and minerals, should be given to rapidly increase weight gain and help the child to recover a normal body composition [9]. These recommendations, however, are often difficult to implement, because the recommended milk-based diets are excellent growth media for pathogenic bacteria. As a result, these diets can only be used under close supervision in specialized units or therapeutic feeding centers, where the quality of water used to reconstitute the feeds can be carefully controlled. This increases the cost of treatment. Also, as a rule, severely malnourished children, especially those who are breastfed, should not be separated from their mothers during rehabilitation. In practice, children can benefit from standard WHO protocol only when their mothers can stay with them for several weeks in residential care, which seriously limits program coverage.

Recently, it has been proposed to replace the liquid milk-based diet used during the recovery phase by a spread with a similar nutritional composition [10]. Presented as Ready to Use Therapeutic Food (RUTF), this spread contains no water, and bacteria do not grow in it as long as it is not mixed with water or a food containing water. RUTF can safely be used at home, even in poor hygienic conditions, without any risk of proliferation of pathogenic bacteria.

RUTF seems to be better accepted by malnourished children than the equivalent liquid milk-based version [10]. Weight gains obtained with RUTF are similar to, if not higher than, those obtained with liquid diets recommended by WHO [11]. RUTF is now increasingly used in relief operations [12], suggesting that spreads may indeed be valuable for this specific application.

The good acceptability of RUTF led to the development of a highly nutrient-dense spread to supplement children with minerals and vitamins missing in their diet. A controlled trial showed this approach to be effective to treat anemia and partially reverse stunting in children aged 30 to 64 months [13]. Development of a spread specifically designed for supplementing infants and young children aged 6 to 24 months, however, has never been attempted.

Potential advantages of spreads for infant feeding

The technological advantages of spreads for formulating foods to supplement vulnerable groups have been described in detail elsewhere [14] and make them good candidates for formulating a FOODlet. Briefly, spreads containing no water are naturally resistant to bacterial contamination. The surface of the fat contained in the spread and in contact with the oxygen from the atmosphere is low compared with that of powdered products, such as flour or powdered milk. Spreads also have a low water activity. As a result, fat oxidation is slower and storage life is increased in spreads compared with similar powdered products. Spreads are not water soluble and have no osmotic activity when put into water, making them well tolerated despite their high energy content. Spreads usually have a pleasant taste, and the unpleasant taste of soluble minerals, which are usually better absorbed than tasteless insoluble salts, can be hidden more easily than in products designed to be prepared with water.

Turning spreads into FOODlets for supplementing infants' diets

RUTF was designed to be given to severely malnourished children, usually older than 12 months. These children are able to eat the spread directly without its being mixed with other foods. They receive the spread for only two or three weeks, a short period during which their attraction toward a new food has no time to wear off. During rehabilitation children are usually hungry, and experimental data suggest that malnourished subjects may prefer fatty foods [15]. Obviously, good results obtained with RUTF for the rehabilitation of severely malnourished children cannot be readily extrapolated to long-term supplementation of younger, well-nourished infants. Several questions need to be answered before spreads can be used as FOODlets to supplement the diets of infants and young children.

Should the spread be consumed as a snack?...

Eating the spread by itself, as a snack, has the advantage of avoiding the risk of bacterial proliferation. Feeding a "snack-spread" to infants, however, is impossible in the absence of proper swallowing reflexes. Also, the ability to regulate water intake independently from food intake should be well established before a snack spread can be used. We have no precise information on the age at which a child can safely eat a spread as a snack. Experience with other hard-to-swallow dry foods, such as biscuits or bread, suggests, however, that infants should be able to safely eat a spread FOODlet as a snack from six to nine months of age, i.e., soon after the introduction of complementary feeding seems warranted, but this requires confirmation.

...or mixed with the food?

Mixing the spread with other foods makes its incorporation into complementary food easy. Spreads have a low viscosity at the temperature of any warm porridge and can be added to it in the same way as one would add butter or margarine. Adding the spread as a FOODlet to prepared infant food before consumption could easily be integrated into existing food recipes with little educational input. Since the addition of a spread to a porridge does not change its viscosity markedly, this approach can be used as soon as the introduction of complementary feeding is warranted, from six months of age.

A spread mixed with the food loses some of its advantages. First, pathogenic bacteria can grow in a porridge fortified with a spread as readily as in any traditional weaning food. This may be hazardous in communities with low levels of hygiene [16]. Second, micronutrients contained in the spread come into contact with antinutrient factors, mainly phytates, contained in the porridge. This is likely to result in reduced intestinal absorption of divalent cations, mainly zinc and iron. Yet, it seems likely that the effect of phytates on mineral absorption can be offset by increasing the fortification levels.

Should the spread be designed as only a vitamin- and mineral-rich supplement?...

The price of minerals and vitamins of chemical origin is so low that the cost of a fortified food is related more to the cost of the food itself than to the cost of the minerals and vitamins used to fortify it [17]. As a result, the cheapest option is to use a small quantity of food fortified with a high level of vitamins and minerals. Along this line, the extreme approach is to prepare "condiment spreads." These spreads should have a strong taste, so that a small amount will be enough to improve the palatability of a local recipe. A strong taste will also eliminate the risk of overdosing. This approach is likely to be the cheapest food-based strategy to provide missing nutrients to poor communities. Yet, consumed in small quantities, these condiment spreads will hardly increase the energy density of the local recipes. These spreads will also have all the disadvantages of spreads designed to be mixed with other foods, as discussed in the previous section.

...or should it also be a significant source of energy?

Spreads have a fat content of at least 30% and an energy value of 478 kcal (2,000 kJ) or more per 100 g. Hence, spreads can be used to boost the energy intake of infants or to increase the energy density of meals to which they are added. Low energy density of complementary feeding is a problem in countries where diluted porridges are commonly used [6]. In this case, substantial amounts of spread should be added, i.e., at least 20 to 30 g per day, to increase the energy intake by 100 to 150 kcal (400 to 600 kJ) or more per day. Fortification levels of the spread should be adjusted accordingly. This approach, however, will increase the cost of adding the micronutrients missing in the diet, because more food will be needed to provide the same amount of micronutrients.

Should peanuts be used to prepare a spread?

The first version of RUTF for severely malnourished children was prepared by replacing part of the dried skimmed milk in the WHO F100 composition with dried lactoserum and peanut butter [10]. Peanut butter is cheap, has a pleasant taste, and is widely available in developing countries. This ingredient has the right viscosity over a large range of temperature for spread preparation and could be used for local production. It has the disadvantage of containing potent antigens that can provoke severe allergic reactions [18]. However, problems of allergy may be less common in developing countries with a high prevalence of parasitic infection [19]. Malnutrition may also minimize allergic reactions [20]. Finally, in places where peanuts are part of the traditional diet, exposure to peanut allergen may occur anyway at an early age or even *in utero* [21].

The technological advantages of peanut butter, its local availability, and its low cost should be put in balance with this potential risk, which may vary in different geographic areas. Different sources of fat with varying degrees of viscosity can be combined to prepare a peanut-free spread, but usually at a slightly higher cost.

. . . and soy flour? or milk proteins?

In addition to peanut butter, RUTF contains dried skimmed milk and lactoserum [10]. The rationale of this choice was to obtain a nutritional composition close to that of the WHO F100 diet, which has a well-established efficacy and contains only milk products as a source of protein. Dried milk products, however, are expensive, and they were replaced by precooked soy flour in the spread designed to supplement large numbers of stunted anemic children in Algeria [13]. Soy products are cheaper, but they have the disadvantage of containing high levels of phytates, which may inhibit the intestinal absorption of divalent cations. Experience with the spread used in the Algerian study suggests, however, that increasing the concentration of minerals added to the spread may compensate for this unfavorable effect. The choice between these ingredients will again depend upon the local cost constraints and differences in efficacy observed in pilot trials.

What fortification levels should be used?

Several supplementation studies have shown a beneficial effect of zinc supplementation for children living in a community with low zinc intake or availability [22]. These studies were carried out with a zinc supplement given in tablets or as a syrup, usually separately from meals. Doses shown to be effective in these studies may not be valid if they are included in a spread, especially when the spread is mixed with food. Also, iron is absorbed mainly in the upper part of the gut [23], and its absorption may be impaired if it remains surrounded by fat when entering the duodenum. Adjustments and repeated field trials will be needed before optimal fortification levels for spread products can be derived from levels used in efficacy trials.

Will a spread be a sound economic choice?

The economic value of a spread as a FOODlet must also be assessed before recommending its use among the poor. Failure of many locally produced complementary foods to have an impact on the nutritional status of the poor can often be traced to their price, which is considerably higher than the local ingredients they are derived from, making them accessible only to the better-off families [6]. The best approach to assess the economic value of a spread is to determine by linear programming its effect on the price of a balanced ration prepared from locally available foods [24]. A spread may be considered a good choice only if its inclusion among locally available foods results in a net reduction of the cost of a balanced diet—a realistic possibility, even in poor populations with limited purchasing power, with a well-designed spread. Different situations can be compared, depending on whether the cost of the spread is supported by a donor or by families, but the main criterion to estimate the chances of success of a FOODlet will be a low cost that will ensure its economical sustainability.

Conclusions

Spreads represent a flexible option to feed young children and infants, either as a separate food or mixed with the local foods to boost their nutritional density. This seems to be a successful option for feeding malnourished children: the weight gain obtained with a spread product during the recovery phase seems as high as, if not higher than, those obtained with traditional liquid food. However, using this approach in a different context is not straightforward, and there is a need to answer several practical questions before this technique can be fully adapted for this new purpose. Repeated field trials assessing the acceptability of different versions of the FOODlet spread and their efficacy may be needed before this stage is reached.

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Effect of maternal dietary vitamin C intake on the level of vitamin C in breastmilk among nursing mothers in Baghdad, Iraq

Haifa I. Tawfeek, Omer M. Muhyaddin, Hana I. Al-Sanwi, and Najat Al-Baety

Key words: vitamin C, nursing mothers, breastmilk, Iraq

Abstract

The vitamin C content of breastmilk was investigated in a group of nursing mothers attending maternal and child health centers in Baghdad during 1998–2000. Two hundred healthy, nonsmoking, 28- to 38-year-old lactating women were studied. Individual samples of breastmilk were obtained for estimation of vitamin C. Dietary data were collected by using 24-hour food recalls. The mean intake of vitamin C was far below the Food and Agriculture Organization/World Health Organization requirement of 26 ± 2.13 (SD) mg/day). The vitamin C content of breastmilk was significantly correlated with the maternal intake of vitamin C ($r = 0.61$, $p < .01$). *The vitamin C content of breastmilk varied with the season. The level was much higher in summer (3.9 ± 1.05 mg/100 ml) than in winter (3.02 ± 2.01 mg/100 ml;* $p < .05$*). This fluctuation indicates the dependence of breastmilk vitamin C on dietary intake. The results show the need to increase the consumption of vegetables and fruits and to monitor maternal ascorbic acid intake.*

Introduction

Vitamin C is an essential component of the human diet. It has significant biological roles, for example, in the synthesis of collagen [1], prevention of atherogenesis [2], prevention of carcinogenesis [3, 4], relation with pulmonary function [5], and prevention of diabetes [6]. Moreover, vitamin C enhances iron absorption [7] and is important in preventing megaloblastic anemia of infancy [1]. Because early childhood is a period of rapid growth, optimal nutrition is of particular importance at this time, and therefore the emphasis in this study was focused on this stage.

Breastmilk is an exceptionally complex biological fluid with more than 200 components [8]. Vitamin C is among the most variable components of breastmilk. According to the literature, the vitamin content of human milk is closely related to the vitamin C balance of the mother [9, 10]. Moreover, there is evidence that breastfed infants develop deficiencies of water-soluble vitamins [11]. The present study was designed to determine the association between maternal dietary intake of vitamin C and the content of vitamin C in the breastmilk of Baghdadi women during the first 26 weeks of lactation.

Materials and methods

Subjects

The 200 mothers who took part in the study were selected from those attending the maternal and child health center in Baghdad. The study design and all project protocols, questionnaires, procedures, and informed consent forms were approved by the Committee of Medical Research at the Ministry of Health and the Medical Committee at the Al-Sheikh Omer Maternal and Child Health Center, Baghdad.

From July 1998 through July 2000, the following eligibility requirements were fulfilled by each woman: the women had been lactating for 1 to 26 weeks postpartum, were between 18 and 38 years of age, were healthy, were nonsmokers, were not taking vitamin C supplements, and were not taking any medicine that had an effect on vitamin C requirements. The eligible women were interviewed by a trained nutritionist, who discussed all aspects of the project with them. The

Haifa I. Tawfeek and Najat Al-Baety are affiliated with the College of Medicine and Public Health Technology, Bab-Al Mudam, in Baghdad, Iraq. Omer M. Muhyaddin is affiliated with the College of Agriculture, University of Baghdad, in Baghdad, and Hana I. Al-Sanwi is with the College of Engineering, University of Baghdad.

mothers were referred to the clinic nurses and doctors when health-related questions arose.

Maternal anthropometric measurements

Body weight, with the subject wearing only scant clothing, was measured to the nearest 0.1 kg with a bathroom scale. Height, without shoes, was measured to the nearest 1 cm with a portable apparatus. Care was taken to ensure that the subjects stood as upright as possible.

Milk samples and processing

Individual samples of midstream breastmilk (2–5 ml) were obtained from each mother. All breastmilk samples were collected between 10:00 and 12:00 hours. The samples were manually expressed by the donor into a clean test tube, refrigerated, transported to the laboratory, and frozen at –20°C until they were processed individually within 24 hours.

Estimation of vitamin C (ascorbic acid) content

The determination of ascorbic acid was based on the method of Egan et al. [12]. Breastmilk ascorbic acid was stabilized immediately with an equal amount of 10% (wt:vol) metaphosphoric acid. The precipitate was removed by centrifugation at 3,000 rpm for 20 minutes (4°C), and the supernatant was stored at –80°C in amber vials until analyzed. Each run of samples was carried out during three months. Ascorbic acid is stable under these conditions [13].

Ascorbic acid is converted to dehydroascorbic acid in the presence of thiourea and copper sulfate. Dehydroascorbic acid was coupled with 2,4-dinitrophenolhydrazine in sulfuric acid to form a derivative that yields a stable brownish-red color. The color was measured spectrophotometrically with a Shimadza Microflow CL-750 spectrophotometer at an optimum wavelength of 540 nm.

Appropriate standards and calibration curves were used. Duplicate samples were run with each assay. Quality control overtime showed a coefficient of variation of 4.5%. All standards were from Fluka (Milwaukee, Wisc., USA).

Data collection

Sociodemographic data on age, marital status, household income, and educational level attained were collected by trained interviewers. Dietary intakes were obtained by the same interviewers using 24-hour food recalls. All of the interviewers had baccalaureate degrees in nutrition and had participated in an intensive training program that included general interviewing techniques, as well as procedures for collecting quantitative dietary data.

Food models and measuring instruments, like those used in home kitchens for food preparation, were employed to assist in the recall of the quantities of foods and beverages consumed the previous day. To verify the information registered by subjects, the nutritionists reviewed the food record in detail with each subject.

The diets were scored for their vitamin C content according to food tables [14]. The daily vitamin C intake was expressed as a percentage of the established Food and Agriculture Organization/World Health Organization (FAO/WHO) requirement of 60 mg/day [15]. Intakes were considered acceptable if they were 66% of the FAO/WHO requirement, marginal if they were 50% to 66% of the requirement, and low if they were less than 50% of the requirement.

Statistical methods

The results are expressed as means (with standard errors and standard deviations) or percentages. The unpaired *t*-test was used to compare means between groups. Linear regression was carried out; $p < .05$ was considered to indicate statistical significance.

Results

Table 1 summarizes the sociodemographic characteristics of the study subjects. The majority (54%) of the women were between 20 and 27 years old, with an average age of 24.6 ± 0.4 (SEM) years. Half (50%) had attained an elementary school education, 22% had attended higher school or had acquired a college degree, and the rest (28%) had no formal schooling. Most of the subjects (90%) were married. Household incomes were generally low. Of those who reported their incomes, 59% had a monthly income below 10,000 Iraqi dinars (ID) (1 US$ = 2,000 ID).

The mean values and distribution of acceptable, marginal, and low intakes of vitamin C are given in table 2. Only about half of the mothers (51%) consumed acceptable levels of the FAO/WHO requirement for lactating women (> 66%).

Table 3 shows the vitamin C content of the breastmilk of the women at different stages of lactation. During the first week of lactation, the vitamin C content was 4.2 ± 2.08 mg/100 ml, and it decreased to 2.5 ± 0.9 mg/10 0ml in the second half of lactation (around six months postpartum).

The vitamin C content of the breastmilk was related to the mother's diet, as shown in figure 1. A significant positive correlation was present ($r = 0.61$, $p <.01$).

The vitamin C content of breastmilk is remarkably low during the winter, 3.02 ± 2.01 mg/100 ml, as compared with 3.9 ± 1.05 ml in the summer. There is a

TABLE 1. Sociodemographic characteristics of the subjects

Characteristic	No. of subjects	%
Age range (yr)[a]		
16–19	32	16
20–23	48	24
24–27	60	30
28–30	36	18
> 31	24	12
Marital status		
Married	180	90
Separated	12	6
Divorced	6	3
Other	2	1
Educational level		
Lower school	100	50
High school	40	20
Some college	4	2
No school	56	28
Monthly household income (ID)[b]		
< 10,000	118	59
10,000–15,000	60	30
> 15,000	22	11

a. Mean age, 24.6 years; SEM = 0.4.
b. ID, Iraqi dinar (1US$ = ID 2,000).

TABLE 2. Distribution of subjects with acceptable, marginal, and low vitamin C intakes[a]

Intake	No.	%
Acceptable[b]	111	53
Marginal[c]	34	16
Low[d]	64	31

a. Mean ± SD = 26 ± 2.13 mg/day.
b. > 66% of the FAO/WHO requirement for lactating women.
c. 50%–66% of the FAO/WHO requirement.
d. < 50% of the FAO/WHO requirement.

TABLE 3. The mean of breastmilk of the lactating women

Duration of lactation (wk)	No. of subjects	Vitamin C (mg/100 ml)
<2	30	4.2 ± 2.08
3–6	55	3.8 ± 1.9
7–14	41	3.2 ± 1.5
15–14	39	3.0 ± 0.9
>24	35	2.5 ± 0.8
0–>24	200	3.4 ± 0.9

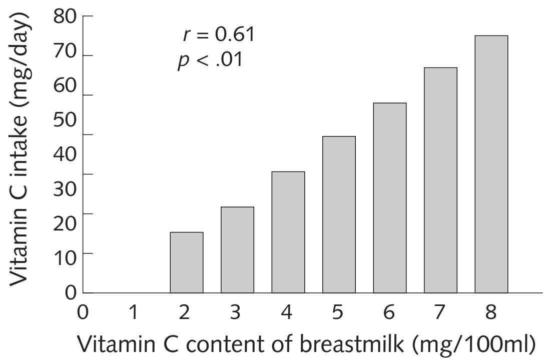

FIG. 1. Relation between mothers' vitamin C intake and vitamin C content of breastmilk

significant difference between the summer and winter seasons ($p < .01$).

Discussion

In the present study, the average vitamin C content of breastmilk was 3.4 ± 0.9 (SD) mg/100 ml (table 3), and the range was 2.2 to 8.08 mg/100 ml (fig. 1). The breastmilk of 51% of the mothers was deficient in vitamin C. This is evidence that the diet of these women contains inadequate vitamin C, since the vitamin C content of breastmilk tends to vary according to the amount in the mother's diet.

An increased vitamin C consumption (up to 51–60 mg/day) will increase the vitamin C in breastmilk up to a certain level (8.1 mg/100 ml), beyond which additional vitamin C will make no difference. This phenomenon needs further research, since there have been reports of an adaptation to low intakes of vitamin C as well [9].

The vitamin C content of breastmilk and the vitamin C intake of the mothers in our study were low, as compared with the findings of others [16]. Higher vitamin C levels were found in both transitional and mature milk [7.60 mg/100 ml (431.6 μmol/L) and 8.73 mg/100 ml (496.1 μmol/L), respectively] in nonsmoking Spanish women.

Our findings agree with those reported in a systematic study of the composition of human milk during the war years in England, in which the mean value of breastmilk vitamin C was 2.0 mg/100 g [17]

In the present study, the postpartum values for dietary vitamin C intakes were lower than the value of 71.1 ± 15 (SD) mg/day reported from Baghdad [18].

Given that the FAO/WHO-recommended dietary vitamin C intake for lactating women [15] is 60 mg/day, it would appear that some women achieve this intake whereas others do not. The lower vitamin C intakes were not due to underreporting of food intake or to incomplete records, since there was no evidence of underreporting and all records were checked.

These results support previous findings that vitamin C intake influences the composition of breastmilk. Ortega et al. [19] found that women who consumed low amounts of fruits and vegetables had significantly lower levels of ascorbic acid in their breastmilk than did women with greater intakes of fruits and vegetables:

4.5 mg/100 ml (255.5 μmol/L), as compared with 437.8 mg/100 ml (37.8 μmol/L).

The use of vitamin C supplements offers another convenient method to ensure the adequacy of this vitamin in the diet. Studies of low-income women in Texas [20] showed supplementation to be an advantage in increasing vitamin C levels in milk, especially in those women whose diets were less than adequate.

A study of 130 nursing mothers in Gambia suggested that maternal supplementation during lactation led to an increase in the ascorbic acid content of breastmilk, since the supplements provided a significant amount of vitamin C [21].

The findings of the present study suggest the need to increase the consumption of fruits and vegetables during lactation through improvement of the government ration program for Iraqi families and the implementation of a nutrition education program. Monitoring of maternal ascorbic acid intake and vitamin C status should be considered.

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A comparison of mothers' knowledge, attitudes, and utilization in relation to soybeans and cowpeas for child feeding in a Nigerian rural area

Folake Olukemi Samuel and Abiodun Hotonou Cole

Key words: child feeding, soybeans, cowpeas, Nigeria

Editorial comment

Soybeans are new to both Africa and South Asia, but they have excellent nutritional value and superior yields in some environments. There are often doubts that will they will prove acceptable for child feeding. This paper demonstrates that given good promotional efforts, they can be successfully introduced.

Abstract

This study assessed rural mothers' knowledge of, attitudes toward, and use of soybeans as compared with cowpeas for feeding their young children. Mothers who had at least one child below the age of five years in 239 sampled households were interviewed. The results indicate that mothers were well informed about the value of giving both foods to their young children. A comparison of attitudes shows that the mothers had a more favorable opinion of cowpeas and that they used cowpeas more than soybeans. Mothers' reasons for using both foods include nutritive value, affordability, and palatability, in that order. Cowpeas were favored for ease of preparation. More mothers introduced cowpeas to their children before the age of six than soybeans.

Introduction

With the increasing cost of foods of animal origin, lower-cost protein sources from plants have become important in Nigeria. Such foods must be not only nutritious and cheap, but also safe and acceptable to local tastes. Cowpeas (*Vigna unguiculata*) have largely fulfilled this role. This versatile, indigenous West African legume has long been popular as a source of protein in Nigeria [1]. The beans are prepared and eaten in a variety of ways, and Nigeria is the greatest consumer of cowpeas in the world [2].

Soybeans (*Glycine max*), a relatively new crop in the country, are less popular than cowpeas, but they have been increasingly consumed in the past two decades. They are a source of good, low-cost protein and have been found valuable in the management of malnutrition, as reported by the Kersey Children's Home, Ogbomoso, Oyo State [3]. Efforts are being made to popularize soybeans for household consumption. This study investigated rural mothers' knowledge of, attitudes toward, and use of soybeans and cowpeas as foods for their young children. It also identifies some inherent problems and provides useful information that can help improve the design and implementation of nutrition intervention programs involving these foods. The study draws on mothers' knowledge of, attitudes toward, and use of indigenous cowpeas to serve as a standard for comparison.

The objectives of the study were to compare mothers' level of knowledge concerning the use of soybeans and cowpeas as foods for their children under five years of age; to assess and compare mothers' attitudes toward the use of each of these foods; and to determine the extent to which soybeans are actually being used as compared with cowpeas.

Methods

The study was carried out in Orire Local Government Area of Oyo State in southwestern Nigeria. This predominantly rural area was selected because of the presence of widespread efforts to popularize soybeans by both governmental and nongovernmental organizations.

A total of 246 pretested structured interview schedules were used to elicit information from mothers who had at least one child below the age of five in the sampled households, which were selected by multistage

The authors are affiliated with the Department of Human Nutrition, University of Ibadan, in Ibadan, Nigeria.

stratified random sampling. Of these, 239 were finally analyzed. Socioeconomic information was collected in addition to data on knowledge of, attitudes toward, and use of soybeans and cowpeas.

Indices of knowledge were developed and based on true," "false," and "don't know" responses. Attitude responses were scored as "agree," "disagree," and "don't know." Positive answers were given a score of two points, negative ones one point, and "don't know" no points.

Utilization was measured by classifying respondents as nonusers (those who had never given either soybeans or cowpeas to their children; 0 points), ex-users (those who had stopped feeding either of the foods after introducing them to their children; 1 point), or regular users (those who were still giving their children either of the foods at the time of interview; 2 points). The mothers were also given a score according to the number of ways that they served these foods to their young children: one way (1 point), two ways (2 points), three ways (3 points), four ways (4 points), and five or more ways (5 points). Frequency of use was classified as daily (4 points), twice a week (3 points), once a week (2 points), and about twice a month (1 point)

Weighted mean scores for overall knowledge, attitudes, and use were calculated and converted to percentages. Scores below 70% were considered low. Testing of hypotheses was carried out using a two-tailed test for differences between mean scores.

Results

Socioeconomic characteristics

The socioeconomic characteristics of the respondents and their children are shown in table 1.

Mothers' knowledge

All but one of the respondents was aware of both soybeans and cowpeas as food for young children; 36.8% of them first learned of this from extension agents, 30% from the maternity clinic, 24.3% from friends or relatives, and 8% from school, religious organizations, television, or radio.

For each of the knowledge items, the respondents scored highest (96.6%) on the item that stated, "Soybeans help young children to grow well." The lowest mean score was for "Soybeans cause overweight in children" (55.3%). "Soybeans cause diarrhea in young children" also scored relatively low (70.5%). For cowpeas, the highest mean score (99%) was obtained for "Beans (cowpeas) help young children to grow well." "Beans cause diarrhea in children" scored 73%. "Beans cause overweight in young children" scored the lowest (63%).

Mothers' attitudes

The results suggest that favorable attitudes toward the use of soybeans have been developed. Most mothers believed that any child (rich or poor, rural or urban) could be fed either soybeans (90%) or cowpeas (99.5%). However, a majority believed that it was not prestigious to feed their child either soybeans (71.1%) or cowpeas (69.5%).

Mothers' utilization

Figure 1 illustrates the pattern of use. A total of 77% were regular soybean users, 17.2% were ex-users, and 5.9% were nonusers. A higher percentage were regular cowpea users (95.8%), 3.3% were ex-users, and 0.8% were nonusers.

Reasons for not using or for discontinuing use included inability of the mother to prepare the food, the child's refusal to eat the food, the laborious and time-consuming preparation of the food, the perishable nature of the food, and the flatulence associated with its consumption. Other complaints were that the child was too young to be given such foods, that the food made the child ill (diarrhea and/or vomiting), or that the mother could not buy it as needed.

TABLE 1. Socioeconomic characteristics of respondents and their children ($n = 239$)

Characteristic	Frequency	%
Age of child (yr)		
<1	61	25.5
1-3	116	48.6
3–5	62	25.9
Mean = 2.14, SD =1.27		
Sex of child		
Male	134	56.1
Female	105	43.9
Age of mother (yr)		
<25	52	21.8
25–34	114	47.7
35–44	57	23.8
≥45	14	5.9
No response	2	0.8
Mother's educational level		
No formal schooling	94	39.3
Primary school	64	26.8
Secondary school	35	14.6
Tertiary school	46	19.2
Mother's occupation		
Farming	102	42.7
Trading	82	34.3
Farming and trading	15	6.3
Teaching	28	11.7
Others	8	3.3
No response	4	1.7

Number of ways that respondents served soybeans and cowpeas to their children

Of the respondents, 78% had served soybeans in three or fewer different ways, 12% in four different ways, and 10% in five or more different ways. Cowpeas had been served in three different ways or fewer by 65.1%, in four different ways by 23.6%, and 11.4% in five or more different ways. Figure 2 illustrates the results.

Frequency and age distribution of regular consumption of soybeans or cowpeas by children

The mothers used cowpeas more frequently than soybeans (fig. 3). Soybeans were introduced before the age of 6 months by 31.3% of the respondents, 41.8% did so between the ages of 6 and 12 months, and 27.1% waited until after their child's first birthday (fig. 4). For cowpeas, 48.5% introduced them before 6 months, 34.2% between 6 and 12 months, and 17.3% after one year.

Mothers' reasons for using the foods

The first three reasons for using the foods, in order of importance, were the same for soybeans and cowpeas.

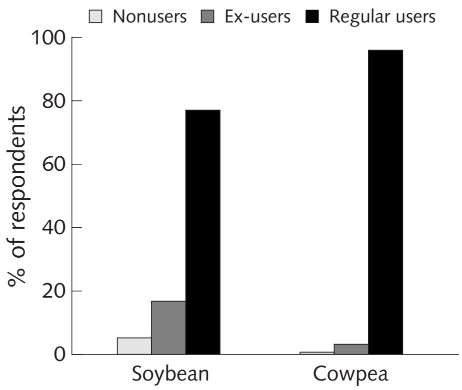

FIG. 1. Pattern of utilization of soybeans and cowpeas

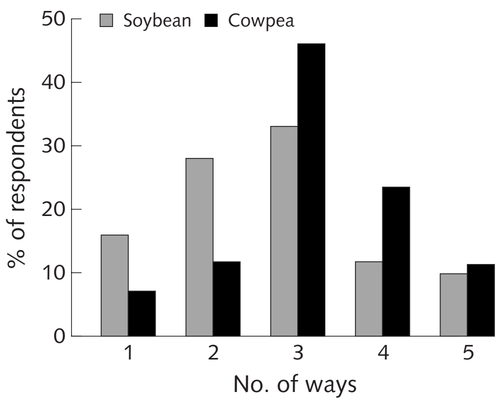

FIG. 2. Number of ways of serving soybeans and cowpeas

The most important factor, chosen by 84.1% (soybeans) and 91.7% (cowpeas) of the respondents, was that the food helped children to grow well. The second was that it was affordable (soybeans 56%, cowpeas 44.5%). The taste of soybeans was acceptable to 32.9%, whereas 41.1% found the taste of cowpeas acceptable.

More than one-quarter of the mothers (26.2%) had used soybeans at one time or another to treat child malnutrition, as compared with 19.7% who had used cowpeas for this purpose. "Because the child asked for them" was cited as a reason for feeding soybeans by 16.9% of mothers and as a reason for feeding cowpeas by 32.3%. Another factor considered important for selecting cowpeas was that they were easy to prepare (34.9%).

Overall mean scores for knowledge, attitudes, and utilization

Each respondent was scored as described earlier, and the weighted mean was calculated. There was a lower level of soybean utilization, despite relatively high levels of knowledge and positive attitudes of mothers toward their use (table 2).

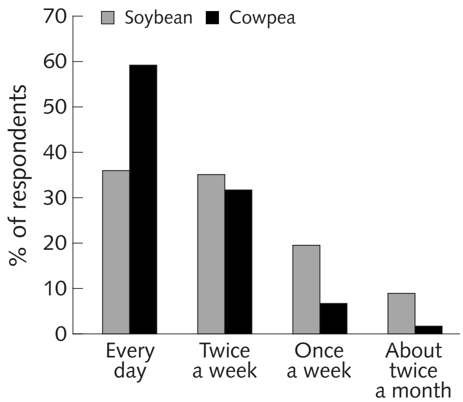

FIG. 3. Frequency of use of soybeans and cowpeas

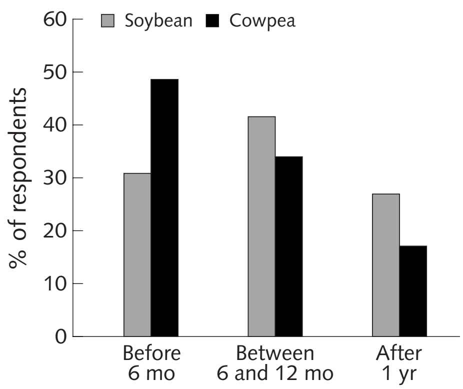

FIG. 4. Age at which soybeans and cowpeas were introduced to children

TABLE 2. Overall mean scores (%) of mother's knowledge of, attitudes toward, and utilization of soybeans and cowpeas

Index	Soybeans	Cowpeas
Knowledge	81.8	82.2
Attitudes	84.8	91.3
Utilization	63.1	75.4

Testing of hypotheses

There was no significant difference between the mothers' knowledge of soybeans and cowpeas. The mothers had significantly better attitudes toward the use of cowpeas than soybeans as food for young children. The mothers' utilization of cowpeas was significantly higher than that of soybeans.

Discussion

The knowledge scores demonstrate widespread maternal knowledge of the benefits and safety of feeding young children with both soybeans and cowpeas. Although knowledge of cowpeas is indigenous, the closeness of the knowledge scores for both foods indicates that soybean popularization messages have been well understood, even given the low level of education of the respondents. Most of the mothers were farmers, and more than half of them grew soybeans on their personal farms. This is a welcome finding, since in 1984 soybeans were virtually unknown and were neither grown nor used in Oyo State [4] or in southeastern Nigeria [5].

Beliefs linking diarrhea and overweight in young children with their consumption of these foods existed among the mothers. The low prestige of both cowpeas and soybeans as food for young children needs to be countered. Mothers' attitudes toward cowpea use were significantly more favorable than those toward the use of soybeans. Furthermore, it appears that mothers were more confident about introducing cowpeas into their children's diet earlier than soybeans. Thus, soybeans have yet to enjoy the reputation that the indigenous cowpea has acquired over decades of popular use. The respondents noted several ways to purchase and prepare soybeans, demonstrating their versatility and the possibilities of incorporating them into a wide variety of local foods.

A similar study carried out in urban Nsukka in the southeastern part of the country showed that soybean was often used in the preparation of milk, *moinmoin*, and eaten with food staples. However, only 51% of those interviewed actually consumed soybeans, and only 22% consumed them two or three times per week [6]. The major reason for consuming soybeans was their high nutritive value, while 68% of those who did not eat soybeans said they were not used to them. Soybeans ranked fourth among legumes in consumption. However, cowpeas still remained the legume of choice. These findings are not surprising, because cowpeas are an indigenous crop and their use has been intricately woven into the fabric of the culture and life of the people.

In the present study, the factors considered important in the selection of soybeans and cowpeas as food were nutritive value, affordability, and palatability, in that order. Among the remaining factors influencing food choice, ease of preparation was considered more important for the selection of cowpeas than for soybeans. It is likely that these women grew up using cowpeas and therefore did not find them difficult to prepare. However, cowpeas are easier to cook and cook faster than soybeans. Because of their lower starch content, soybeans do not swell or soften as readily and must be boiled for a longer time.

Conclusions

Achieving sustainable acceptance and adoption of soybeans can be helped by correcting erroneous impressions, improving attitudes, and developing appropriate technology that will cut down considerably on labor, time, and fuel, while at the same time maintaining acceptable organoleptic properties of soybean foods. It should be emphasized that the campaign for better utilization of soybeans does not aim to displace the indigenous cowpeas but to compensate for the scarcity and cost of cowpeas and other more expensive protein sources, allowing children to consume a nutritious supplement at a much lower price.

Acknowledgments

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Malnutrition in food-surplus areas: Experience from nutritional surveillance for decentralized planning in Haiti

Menno Mulder-Sibanda, Flora S. Sibanda-Mulder, Lydia d'Alois, and Daniel Verna

Key Words: Haiti, malnutrition, nutritional surveillance

Abstract

In Haiti, a novel approach to nutritional surveillance was developed on the basis of a low-cost, simple-to-repeat set of household surveys in all nine administrative departments using sentinel community sites. This system allows each department to independently conduct follow-up surveys as needed. The results of the first round of surveys conducted in 1995 show lower malnutrition rates in typical food-deficient departments and high levels of malnutrition in several food-surplus areas. Further analyses underscore the importance of variables related to child-care practices and of care-enabling factors such as household food security, health environment, and caregivers' time and education. These findings challenge the traditional thinking among a majority of Haitian policy makers who look at the malnutrition problem solely from the perspective of local food production.

Introduction

In 1986, Haiti saw an end to approximately three decades of exploitative authoritarianism. Thereafter, the country experienced political instability characterized by short reigns of military governments punctuated by equally short civilian rule, various coups d'état, and several attempts at presidential elections. Following the 1991 coup d'état, the political situation escalated into a standoff between the Haitian military government and the international community. The Organization of American States, later joined by the United Nations, condemned the coup and imposed an economic embargo that lasted up to October 1994.

Before the economy went into a sanctions-induced recession, Haiti was already the poorest country in the Western Hemisphere, with some of the worst indices of social deprivation. Life expectancy is 57 years. The 1990–1994 child mortality rate is estimated at 131 per 1,000, 41% of children 48 to 59 months of age are stunted, and half of the population is illiterate [1, 2]. Notwithstanding, the political mismanagement that followed the 1991 coup d'état was detrimental to the already inadequate infrastructure of public services, including agricultural extension, education, and health care [3, 4]. This was compounded by the fact that there was no surveillance system in place to generate reliable population-based data to monitor the effects of the political crisis.

One of the challenges facing the current government is repairing the damage, which includes a recent increase in acute malnutrition [5], through the inadequate mechanisms of a severely weakened public sector. The government has adopted a multipronged development strategy, which includes decentralizing decision-making and delegating the responsibility for service delivery to the nine departments, i.e., the first level of administrative and geographic division of the country. Unsurprisingly, the lack of nutrition-relevant information according to region became a severe handicap in the identification of priority areas, the design of appropriate programs, and the allocation of limited resources.

To support the government's new decentralization strategy, a joint effort of the Ministry of Health, the Pan American Health Organization/World Health Organization (PAHO/WHO), and UNICEF resulted

Menno Mulder-Sibanda, a nutrition officer for PAHO/WHO in Port-au-Prince, Haiti, is currently working as an independent nutrition consultant based in Abidjan, Côte d'Ivoire. Flora S. Sibanda-Mulder, chief of the health section for UNICEF in Port-au-Prince, is currently a regional advisor on women's health and nutrition for UNICEF's West and Central Africa Regional Office. Lydia d'Alois is affiliated with Capital Consult, a consulting firm in Port-au-Prince. Daniel Verna, health project officer for UNICEF in Port-au-Prince, is currently the health project officer for UNICEF in Bujumbura, Burundi.

in a series of low-cost household-level surveys according to department using sentinel community sites. The surveys had two objectives: to provide representative household-level data on the nutritional conditions, such as the prevalence of undernutrition and morbidity in children under five years of age, child-care practices, and socioeconomic characteristics; and to establish a community-based surveillance system that can provide regular (as needed) and dependable information to policy makers and planners at central and decentralized decision-making levels. The information could enable identification of national and regional priorities, as well as planning and evaluation of nutrition-relevant programs. This paper includes a description of the surveillance system design, survey methodology, and a discussion of the main results.

Methods

The national nutritional surveillance system

The national nutritional surveillance system was developed in 1994. The system was designed to respond to a situation that was characterized by a virtual absence of systematic approaches for the collection, interpretation, and use of nutrition-relevant information through a mechanism that has the ability to articulate national priorities; limited availability of nutrition-relevant data beyond anthropometric indicators, which underscore the problem of widespread malnutrition, but not its causes; availability of national survey data on the one hand and ad hoc local survey data on the other hand, which provide inadequate information necessary for planning at the regional level; and lack of household data, which leads to over-reliance on unrepresentative institution-based data.

The nutritional surveillance strategy that was developed is composed of three major components: comprehensive and analytical description of the nutrition situation using data and findings from secondary sources (repeated at approximately 10-year intervals); household surveys according to departments (repeated as needed at approximately 5- to 10-year intervals); and punctual and rapid assessments, using anthropological techniques, as well as in-depth studies on specific problems that draw from results of the household surveys.

Thus, the nutritional surveillance system is expected to go beyond the statistical description of malnutrition and associated factors in a similar fashion as the Ethiopia National Nutritional Surveillance System [6]. Between the household surveys, in-depth assessments and analysis can be employed to guide policy and program recommendations through up-to-date information. A novel aspect of the Haitian surveillance system is that the departmental authorities can decide, based on local circumstances, when the household survey needs to be repeated. In addition to the core module that is provided by the central level, departments can modify indicators to suit their local conditions. At the central level, a comprehensive situation analysis is conducted approximately once every 10 years by reviewing results from the household nutrition surveys as well as other sources of information, including household budget and expenditure surveys, morbidity and mortality surveys, market studies, knowledge, attitudes, and practices (KAP) studies, and so on.

Given the fact that the system has recently been established, it is too soon to evaluate how well it will perform in the long run. The sustainability of the surveillance system will depend on the decision makers' interest in ensuring the availability of reliable data. This aspect was taken into account in the conception of the surveillance system through the use of the Ministry of Agriculture's crop surveillance sites. These sites were used where possible and complemented with new ones where necessary. This approach aims at facilitating collaboration between the two ministries, reducing the costs for each ministry's surveillance activities to promote the use of the surveillance system, and enhancing both the breadth and the depth of data analysis.

Since the development of the surveillance system in 1994, a situation analysis has been conducted, as well as a household survey in all nine departments and in the Port-au-Prince metropolitan area.

Household surveys

The design of the methodology for the household surveys took into consideration the need for representative data from each department and a simple-to-repeat, low-cost information-gathering system. This resulted in a random area cluster sample stratified by six categories of agroecological characteristics, including two categories of urban residence. Each department was treated as a separate survey domain with equal sample sizes. In addition, the capital, Port-au-Prince, with over 25% of the population, was treated as a separate survey domain. Sparsely populated islands were excluded, mainly for logistical reasons.

Cluster areas refer to small geographic areas with homogeneous agroecological characteristics identified under the Agricultural Development Support for the Ministry of Agriculture as part of a crop surveillance program. The sampling unit was defined as all children under five years of age. Using a prevalence of 10% to 15%, with particular reference to wasting, and a cluster effect of two, a sample size of 400 children is required to arrive at a confidence interval of plus or minus 5%. The selection of sampling units followed the same procedure in each of the 10 survey domains. First, 20 cluster areas were randomly selected, such that at least two segments were taken from each of the six possible agroecological categories. Next, the first household was selected randomly, and all available children under five were included in the survey. The survey team then moved to the next nearest household until a total of 20 children had been surveyed. This resulted in representative samples of 400 children per survey domain, or 4,000 children in the entire survey. However, to reduce possible unit bias, the selection process was spread over a wider area by choosing every other child, which does not affect the relative chance of being included in the survey.

Anthropometric data were collected on all children aged zero to 59 months and included weight, height, and mid-upper-arm circumference. The questionnaire included nutrition-relevant indicators such as child morbidity, child-feeding practices, sanitation, source of drinking water, food consumption, assets, distance to the nearest health center, and various aspects of the caregiver's reproductive history.

The interview with the child's principal caregiver, i.e., the person responsible for day-to-day decisions concerning the child, which in most cases is the mother, lasted approximately half an hour and was designed to provide broad indicators of the "food, health, and care" dimensions in child nutrition [7]. Unfortunately, the "food" dimension is the least represented in the final dataset. This is due to the difficulty of operationalizing food security in a 30-minute survey questionnaire and the widespread fear and distrust among respondents that makes it virtually impossible to collect sensitive economic information at the household level. Several proxy indicators of household income level and wealth status were considered, such as outstanding food-consumption loans, source of food in the last seven days, and land ownership. However, various of these indicators could not be applied successfully during the field-testing or data-collection stages, because many respondents had given unreliable answers. Only the following two indicators produced credible results: whether or not the caregiver had consumed animal protein foods in the 24 hours preceding the interview, as a proxy of current food security; and a household-level wealth score based on ownership of various household commodities, such as private toilet, private water source, and radio. The indicators have been organized by category. Child-care practices are grouped as direct determinants of child's health, dietary intake, and nutritional status. The categories of underlying factors determining the way children are cared for include food and economic resources, human resources for child care, time and organizational support for child care, and health services, water, and sanitation/environment [8].

Data collection was carried out in the last quarter of 1995. Training and supervision of data collectors were assured by the central level in an effort to ensure the comparability of data from each department. It will be important to follow a similar approach in future rounds of data collection, particularly when departments start following different calendars of data collection. Twenty-eight enumerators were selected from a total of 70 candidates. At the end of the training, the enumerators had to conduct anthropometric assessments within error values of ±0.3 cm for length and height, ±0.1 kg for weight, and ±0.25 cm for mid-upper-arm circumference, as compared with reference measurements from the principal trainer. Data collection was carried out by teams of two enumerators. The 14 data-collection teams were supervised by three field managers, each responsible for four to five teams. Frequent meetings were held with enumerators and supervisors during the data-collection period to ensure high levels of interviewing techniques, questionnaire completion, and anthropometric measurement skills.

Data entry was completed on personal computers using Epi Info 6 (Centers for Disease Control and Prevention, Atlanta, Ga., USA). The module Epi Nut was used for anthropometric conversion into standard deviation values (Z scores) in relation to the National Center for Health Statistics/World Health Organization (NCHS/WHO) reference population. All stages of quality control were followed in the process of data collection and data entry, including verification of the completed questionnaires at all supervisory levels and data entry with internal verification. After all data had been entered and before starting the analyses, a final verification and cleaning of the database was conducted, including comprehensive verification of all Z scores outside the –5.5 to +5.5 range. Further details are contained in the main report of the survey [9].

Reliable population weights required for department-level estimates were not available, because current population estimates are derived, through fixed projections, from the obsolete 1982 census. Considerable population movements occurred with the advent of the political crisis. Therefore, the sampling errors of the estimated malnutrition rates are likely to be underestimated. SPSS/PC 5 was used for data analyses (SPSS Inc., Chicago, Ill., USA). Associations were explored by one-way analysis of variance of anthropometric indices by various immediate and underlying determinants of nutrition according to the UNICEF conceptual framework of nutrition [7]. Multivariate linear regression was used to assess the strength of associations with anthropometric outcomes as dependent variables while controlling for other factors. Spearman's rank correlation coefficients were computed to evaluate the degree of association between two separate rankings of survey areas.

Decision makers are most interested in the prevalence of malnutrition to establish public health and nutrition priorities. Hence, the prevalence of malnutrition is estimated by identifying and counting malnourished individuals using a cutoff point of –2 Z scores [10]. The resulting prevalence indicators are wasting (weight-for-height), underweight (weight-for-age), and stunting (height-for-age). The application of this method reflects the presence of severe malnutrition, that is, children at the extreme end of the distribution [11].

Results

Of the 200 preselected cluster areas, 5 had to be replaced because of logistical and political inaccessibility. Data were collected from 4,000 child–caregiver units, of which 3,968 (99.2%) were usable. Girls made up 51.5% of the children under five year old.

The estimated prevalence of malnutrition is shown in table 1. Considerable differences in prevalence are observed between the least and most affected survey areas. Table 1 shows that the prevalence of stunting varied from 25% (Port-au-Prince) to 38% (Center). The variation is equally large for the prevalence of underweight (Port-au-Prince, 18%; Center, 29%), confirming the results from measurement of height deficits. The prevalence of wasting is characterized by relatively higher differences between survey areas (Port-au-Prince, 3%; Grand'Anse, 9%).

The analyses that follow are not meant to identify causes of malnutrition and growth failure, since cross-sectional data cannot easily distinguish cause from effect. Instead, the associations that are identified illustrate the multidimensional nature of nutrition, and the results can be used for advocacy to improve nutritional well-being by appropriate actions.

Following the UNICEF framework, table 2 shows the mean weight-for-height (WHZ) and height-for-age (HAZ) Z scores by age according to immediate determinants of malnutrition, including diarrhea, and selected child-care practices. Most practices demonstrate significant associations with mean HAZ in children less than two years of age and with mean WHZ and HAZ in children above two years of age.

TABLE 1. Prevalence estimates of malnutrition (< –2 Z scores) by survey domain[a]

Domain	Wasting	Underweight	Stunting
Center	7.2	29.3	38.2
Grand'Anse	8.6	27.8	36.2
North	6.4	27.1	35.2
West	4.1	23.9	34.4
South	5.8	25.3	33.1
Southeast	5.3	25.4	31.1
Northeast	4.7	24.0	27.6
Artibonite	7.0	25.1	27.1
Northwest	5.4	22.3	26.4
Port-au-Prince	2.8	17.5	24.7

a. Survey areas are listed by descending order of stunting prevalence.

Most indicators confirm similar patterns in the mean WHZ in children zero to 23 months old. However, only two indicators—diarrhea in the last 15 days and measles immunization coverage—demonstrate sufficient contrast to bring the significance level below 5%. Ostensibly, weight-for-height among younger children is associated with immediate determining factors other than those mentioned here.

The association of underlying determinants of children's nutritional status and growth is evaluated in table 3. The mean WHZ and HAZ values seem to differ between boys and girls, with girls slightly better off than boys, particularly with respect to HAZ in the first two years of life. Residence environment is associated with nutritional outcomes. The Port-au-Prince metropolitan area has the lowest prevalence of malnu-

TABLE 2. Mean weight-for-height (WHZ) and height-for-age (HAZ) Z scores by age category according to immediate determinants of nutritional status

Determinant	WHZ < 24 mo	WHZ ≥ 24 mo	HAZ < 24 mo	HAZ ≥24 mo
Diarrhea in last 15 days				
No	–0.34[a]	–0.42[a]	–0.80[a]	–1.68[a]
Yes	–0.47	–0.63	–1.00	–2.10
Child's hands washed before last meal[d]				
No	–0.54	–0.43	–0.97	–1.84[b]
Yes	–0.47	–0.47	–1.09	–1.70
Child fed vitamin A–rich food in last 24 h[d]				
No	–0.51	–0.56[a]	–1.09	–1.86[a]
Yes	–0.46	–0.38	–1.03	–1.66
Child fed animal protein in last 24 h[d]				
No	–0.52	–0.50[a]	–1.11[c]	–1.94[a]
Yes	–0.45	–0.41	–0.99	–1.51
Weaning age[e]				
< 12 mo	–0.53	–0.46	–1.59[a]	–1.69
≥ 12 mo	–0.60	–0.45	–1.23	–1.75
Health record				
No	–0.35	–0.66[a]	–0.76[c]	–2.17[a]
Yes	–0.39	–0.42	–0.90	–1.68
Measles vaccination[d]				
No	–0.73[a]	–0.63[a]	–1.52[a]	–2.07[a]
Yes	–0.54	–0.41	–1.20	–1.66
Type of health care for child's last illness				
Modern	–0.47	–0.56[a]	–0.87	–1.90[a]
Traditional	–0.41	–0.42	–0.90	–1.71

a. $p < .05$ (two-tailed ANOVA).
b. $.05 < p < .10$.
c. $.10 < p < .15$.
d. Children aged 6–59 months.
e. Children aged 12–59 months.

TABLE 3. Mean weight-for-height (WHZ) and height-for-age (HAZ) Z scores by age category according to underlying determinants of nutritional status

Category	Variable	WHZ		HAZ	
		<24 mo	≥ 24 mo	<24 mo	≥ 24 mo
Sex and residence	Sex				
	Male	−0.43[c]	−0.45	−0.99[a]	−1.83[a]
	Female	−0.35	−0.46	−0.77	−1.68
	Residence				
	Rural	−0.35[a]	−0.49[a]	−0.90	−1.87[a]
	Urban	−0.56	−0.47	−0.84	−1.50
	Port-au-Prince	−0.34	−0.21	−0.77	−1.40
Food and economic resources	Caregiver consumed animal protein				
	food in last 24 h	−0.38	−0.51[a]	−0.95[a]	−1.94[a]
	No	−0.40	−0.39	−0.79	−1.48
	Yes				
	Household wealth status				
	Relatively low	−0.42[c]	−0.53[a]	−0.92[i]	−1.94[a]
	Relatively high	−0.34	−0.35	−0.81	−1.47
Water, sanitation, and health services	Use of latrine				
	No	−0.45[a]	−0.56[a]	−0.89	−1.95[a]
	Yes	−0.33	−0.35	−0.86	−1.54
	Water source				
	Not potable	−0.40	−0.51[a]	−0.82[b]	−1.86[a]
	Potable	−0.38	−0.39	−0.94	−1.61
	Time to travel to nearest health center				
	≤ 1 h	−0.39	−0.42[a]	−0.87	−1.64[a]
	> 1 h	−0.39	−0.56	−0.94	−2.07
Time and support for child care	Caregiver's absence in last 24 h				
	≤ 1 h	−0.36[b]	−0.46[d]	−0.81[a]	−1.76
	> 1 h	−0.48	−0.40	−1.03	−1.70
	Number of children under 5 yr old				
	1–2	−0.40	−0.44[a]	−0.88	−1.74
	≥ 3	−0.37	−0.65	−0.93	−1.84
	No. of adults per child under 5 yr old				
	< 2	−0.31[b]	−0.59[a]	−0.86	−1.69
	≥ 2	−0.42	−0.43	−0.90	−1.76
	Caregiver's relation to child				
	Mother	−0.38	−0.44[b]	−0.86[d]	−1.73[d]
	Other	−0.40	−0.53	−1.02	−1.85
Human resources for child care	Caregiver's current age				
	≤ 21 yr	−0.33	−0.23[a]	−0.82	−2.21[a]
	> 21 yr	−0.39	−0.44	−0.83	−1.66
	Caregiver's age at 1st pregnancy				
	< 18 yr	−0.37	−0.47	−0.99[a]	−1.86[a]
	≥ 18 yr	−0.36	−0.41	−0.76	−1.63
	Number of pregnancies of caregiver				
	< 7	−0.36[a]	−0.42[a]	−0.86[d]	−1.73[c]
	≥ 7	−0.57	−0.58	−0.99	−1.85
	Type of birth attendant				
	Traditional birth attendant or other	−0.42[a]	−0.49[a]	−0.93[a]	−1.86[a]
	Medical doctor or nurse	−0.22	−0.35	−0.65	−1.35
	Mother's age at child's birth				
	< 20 yr	−0.35	−0.33[c]	−0.92	−2.10[a]
	≥ 20 yr	−0.38	−0.44	−0.81	−1.64
	Length of caregiver's education				
	< 4 yr	−0.48[a]	−0.52[a]	−0.90	−1.88[a]
	≥ 4 yr	−0.22	−0.32	−0.81	−1.43

a. $p < .05$ (two-tailed ANOVA).
b. $.05 < p < .10$.
c. $.10 < p < .15$.
d. $.15 < p < .20$.

trition and growth retardation in the country. Children in rural Haiti seem to be worse off, particularly in terms of low HAZ in the group 24 to 59 months of age.

Household wealth status is associated with WHZ and HAZ in older children and only with HAZ in children less than two years of age (table 3). Interestingly, WHZ in children less than 24 months of age is mainly associated with caregiver's education, the type of birth attendant, the number of pregnancies, caregiver's time spent away from the child, and the number of adults per child under five years old.

Naturally, these associations may be the result of confounding by other variables, especially socioeconomic status, distance to the health center, caregiver's age and education, and residence area. Multivariate regression analyses of anthropometric indices (dependent variable) with underlying determinants as well as diarrhea (independent variables) were carried out to control for the effect of confounding factors.

The results for weight-for-height and height-for-age are shown in tables 4 and 5, respectively. Diarrhea remains significantly associated with WHZ and HAZ in both age groups. The proxy indicator of current food security, consumption of animal protein by the caregiver, is significantly associated with WHZ and HAZ in children aged 24 months and above but not in younger children. Household wealth status is associated with linear growth (HAZ) in children of both age groups. In addition, wealth status demonstrates a slightly weaker association with WHZ in 24- to 59-month-old children. Various proxy indicators of caregivers' social and physical status continue to demonstrate significant association with WHZ in children less than 24 months of age and HAZ in children aged two years and above.

Discussion

The 1995 nutrition surveys by department, which provided a wealth of information on the distribution of malnutrition across the country and on socioeconomic factors that are associated with differences in nutritional status and growth, have identified vulnerable groups that deserve special considerations and further investigation. These findings have implications for future survey rounds as well as for the way policy makers perceive the country's nutritional problems. In addition to these findings, evidence for which has been provided in this paper, the 1995 surveys documented high rates of diarrhea in children, poor water and sanitation conditions, inadequate health service infrastructure, suboptimal infant- and child-feeding practices, and a high proportion of uneducated caregivers.

The survey found that malnutrition is extremely common in young children. Wasting, as indicated by WHZ < –2, was found in 3% to 9% of all children under five years of age, and between 25% and 38% of all children were stunted. Comparative data are available from the 1994–1995 Demographic and Health

TABLE 4. Results of multivariate linear regression analyses of weight-for-height Z scores by age category with underlying determinants of nutritional status

	< 24 mo		≥ 24 mo	
Independent variable	β coefficient	*t*	β coefficient	*t*
Diarrhea in last 15 days (dummy)	–0.128	–1.91[c]	–0.190	–2.82[a]
Male sex (dummy)	–0.082	–1.25	0.030	0.59
Child's current age (mo)	–0.033	–6.48[a]	–0.004	–1.76[c]
Caregiver consumed animal protein in last 24 h (dummy)	–0.048	–0.72	0.108	2.03[b]
Household wealth status (dummy)	–0.049	–0.45	–0.140	–1.69[c]
Latrine use (dummy)	0.056	0.53	0.270	3.35[a]
Access to potable water (dummy)	0.053	0.72	0.015	0.25
Time to travel to health center (min)	–0.000	–0.25	–0.001	–0.95
Caregiver's absence in last 24 h (min)	–0.000	–1.22	0.000	0.67
≥ 3 children under 5 yr old (dummy)	0.019	0.15	–0.123	–1.35
< 2 adults per child under 5 yr old (dummy flush left the above 2 lines	0.018	0.21	–0.223	–3.05[b]
Principal caregiver is biological mother (dummy)	–0.081	–0.61	0.196	2.30[b]
Caregiver's current age (yr)	–0.008	–1.06	0.003	0.59
Caregiver's age at 1st pregnancy < 18 yr (dummy)	0.045	0.55	–0.060	–0.87
Caregiver's age at time of birth < 20 yr (dummy)	–0.185	–1.60	0.118	1.21
Multigravida caregiver ≥ 7 pregnancies (dummy)	–0.111	–0.95	–0.148	–1.83[c]
Skilled birth attendant (dummy)	0.192	2.24[b]	0.036	0.54
Caregiver's education (yr)	0.025	2.27[b]	0.010	1.18
Port-au-Prince residence (dummy)	0.087	0.69	0.154	1.56
Rural residence (dummy)	0.333	3.67[a]	0.049	0.69
Intercept	0.123	0.44	–0.610	–2.74[a]

a. $p < .01$.
b. $p < .05$.
c. $p < .10$.

Survey (DHS), which was conducted one year earlier, from July 1994 to January 1995 [2]. The DHS provided national prevalence estimates for wasting (8%), underweight (28%), and stunting (32%), suggesting a higher level of wasting and similar levels of stunting and underweight.

The traditional belief among policy makers is that levels of food production are directly related to household food security and nutritional status. Therefore, these findings have come as a surprise, since the Northwest Department has always been considered as having the greatest food deficits and therefore as being most prone to famine [12]. The Northwest Department is one of the least developed areas of the country, with barely any agricultural potential due to poor rainfall and soil quality [13]. Conversely, the Grand'Anse, the North, and the Artibonite Departments are often perceived as food-surplus areas with an overall wealthier population. Figure 1 shows the extent to which these general assumptions are supported by 1990–1994 production estimates expressed in kilograms per person [14]. The tubers include cassava, yam, taro, and sweet potatoes; the grains include rice, maize, and sorghum. Four departments, including the Center, Grand'Anse, the South, and the North, are characterized by high levels of food production per capita (more than 300 kg/person) compared with the rest of the country (less than 200 kg/person). Although the Artibonite Department is the principal producer of rice, it produces relatively little else and is the fourth most densely populated department. Conversely, the Northeast, the Center, and the Northwest are the three least densely populated departments. The extent to which the ranking of departments by food production is correlated with the ranking by prevalence of growth deficits or malnutrition is shown in table 6. The anthropometric data of Port-au-Prince and the (rest of the) West Department were merged on the basis of estimated

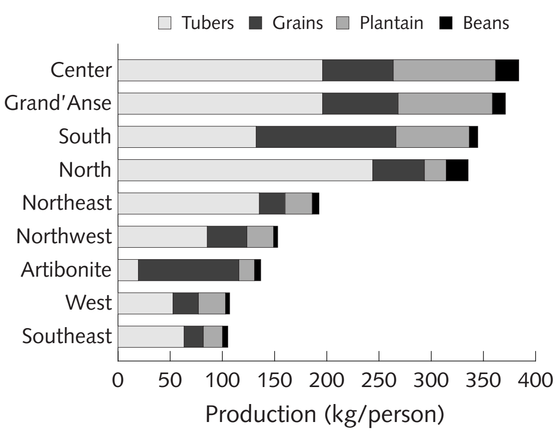

FIG. 1. Average annual food production per person, 1990-1994. Source: ref. 14

TABLE 5. Multivariate linear regression analyses of height-for-age Z scores by age category with underlying determinants of nutritional status

	< 24 mo		≥ 24 mo	
Independent variable	β coefficient	*t*	β coefficient	*t*
Diarrhea in last 15 days (dummy)	–0.253	–2.94[a]	–0.504	–4.45[a]
Male sex (dummy)	–0.279	–3.33[a]	–0.121	–1.41
Child's current age (mo)	–0.072	–11.06[a]	–0.021	–4.90[a]
Caregiver consumed animal protein in last 24 h (dummy)	0.131	1.54	0.313	3.51[a]
Household wealth status (dummy)	0.322	2.32[b]	0.313	2.26[b]
Latrine use (dummy)	–0.183	–1.35	–0.094	–0.70
Access to potable water (dummy)	–0.232	–2.49[b]	–0.147	–1.49
Time to travel to health center (min)	–0.001	–1.63	–0.001	–0.62
Caregiver's absence in last 24 h (min)	0.000	0.14	0.000	0.83
≥ 3 children under 5 yr old (dummy)	–0.243	–1.53	–0.063	–0.41
< 2 adults per child under 5 yr old (dummy) flush left the above 2 lines	–0.018	–0.17	0.185	1.51
Principal caregiver is biological mother (dummy)	–0.122	–0.72	0.085	0.59
Caregiver's current age (yr)	0.013	1.39	0.028	2.88[a]
Caregiver's age at 1st pregnancy < 18 yr (dummy)	–0.155	–1.47	–0.008	–0.07
Caregiver's age at time of birth < 20 yr (dummy)	0.016	0.11	–0.329	–2.02[b]
Multigravida caregiver ≥ 7 pregnancies (dummy)	–0.092	–0.61	–0.241	–1.78[c]
Skilled birth attendant (dummy)	0.139	1.28	0.244	2.18[b]
Caregiver's education (yr)	–0.015	–1.04	0.038	2.58[a]
Port-au-Prince residence (dummy)	0.055	0.35	–0.083	0.50
Rural residence (dummy)	0.580	0.50	–0.092	–0.77
Intercept	–0.130	0.36	–1.912	–5.10[a]

a. $p < .01$.
b. $p < .05$.
c. $p < .10$.

TABLE 6. Spearman's rank correlation coefficient (Rs) between food production levels and each of the three indicators of malnutrition prevalence according to department

Indicator	Rs
Wasting	0.70[a]
Underweight	0.67[a]
Stunting	0.67[a]

a. Statistically significant ($p < .05$).

1994 population weights. The results suggest a positive correlation between food-production levels and prevalence estimates of malnutrition in such a way that departments with a high level of per capita food production have a high rate of malnutrition in children. Undoubtedly, these results suggest that children's nutritional status and growth are influenced by other factors besides the level of food production.

Diarrhea is strongly associated with wasting and stunting in children under five years of age. Elsewhere, it has also been identified as the number one cause of death among children aged 1 to 59 months [2], and it disproportionally affects children under 24 months of age [15]. Studies have shown that inadequate infant-feeding practices are a major underlying cause of diarrhea in young children [16, 17]. In Haiti, although the rate of initiation of breastfeeding is high (96%), the rate of exclusive breastfeeding for six months is less than 1% [2]. Other harmful practices that are widely prevalent in Haiti include delaying the initiation of breastfeeding by 24 hours or more (in more than 40% of newborns), bottle-feeding (between 30% to 40% in the first three months), and early introduction of complementary foods (90% of children aged two to three months) [2, 15].

Economically tainted variables, particularly the caregiver's consumption of animal protein foods as a proxy for current food security, are associated with nutritional status and growth performance in children aged two years and above, but not with that of younger children. Similar results were found in Ethiopia, where the proxy indicator for household food security was also associated with growth performance in older but not in younger children [6], and in Guatemala, where annual family per capita income was associated with no differences in the nutritional status of children 3 to 30 months old, but with marked differences in children 36 to 60 months of age [18]. This selective association may be caused by the relative importance of child care in the first two years of life versus multiple factors that are associated with the household's socioeconomic status in subsequent years.

Caregiver's education, presence of a skilled birth attendant, multigravida caregivers, and teenage motherhood are significantly associated with nutritional status (according to WHZ) in children less than 24 months of age and growth performance (according to HAZ) in children aged two years and above, when other factors are controlled for. The association between anthropometric indices and various indicators in the category of human resources for child care is striking. These indicators partly reflect the social and physical status of caregivers, which have been the focus of recent discussions on caregiving capacity [19, 20].

These findings have important implications for strategies to reduce childhood malnutrition and growth retardation in the country. The results that are presented here clearly indicate that despite traditional notions about the consequences of low levels of food production, the Northwest Department is not the most affected area nutritionally, as was expected by most policy makers and program planners. This implies that programs that aim to improve nutrition by enhancing local food production may not have the expected outcomes. Instead, renewed attention to nutrition, through both research and action, is needed in other departments, particularly those that are typical food-surplus areas. In addition to household food security, health service infrastructure, and water and sanitation conditions, attention should be paid to the families' caring capacity. This includes the role, status, and resources of the caregiver in relation to the adequacy of child-care practices. Given the apparent importance of caregivers' physical and social status, future surveys may wish to include additional indicators of the current health and nutritional status of the caregiver. These include morbidity, mid-upper-arm circumference, and even weight and height at a later stage. Evidence of widespread malnutrition among women is provided by the recent Demographic and Health Survey, which found that 18% of women aged 14 to 49 years had a body mass index below 18.5 kg/m^2 [2].

The relative importance of income and household food security, together with child care, child feeding, health care, water, and sanitation, has long been recognized by researchers and technicians in the field [21–23]. Policy makers, however, have been slow in adopting these notions and until recently remained focused primarily on increasing local food production as the fundamental strategy for improving nutrition. Such persistent misperceptions about the nature of nutritional problems has been identified as one of five reasons that weaken the link of nutritional surveillance to the decision-making process [24].

Unlike national anthropometric surveys, the surveys by department allow for interdepartmental comparison of prevalence estimates as well as intradepartmental analyses of underlying factors. In addition, repeat surveys can be conducted at the departmental level, enhancing the planning capacity at the decentralized level. This decentralized data-collection system has provided new insights into the nutritional problems of the country in a way that few of the country's decision makers had anticipated and has helped to underscore the relative importance of other factors (besides production of food) for children's nutritional status and growth, such as health services, water, sanitation, household food security (as the ability to acquire quality food), and caregivers' social and physical status. Other potential advantages of a sustained decentralized surveillance system include decentralized decision-making, which should be seen as an improved method of designing and implementing regionally specific interventions [25]; more flexibility regarding the timing as well as the contents of data collection, since departments can decide independently to conduct a repeat survey; and increased cost-effectiveness, as decision-making regarding data collection moves closer to the level of program planning.

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Recommendations for the use of body mass index for the classification of overweight and obese children and adolescents

Marcelo Militão Abrantes, Joel Alves Lamounier, and Enrico Antônio Colosimo

Key words: body mass index (BMI), nutritional evaluation, anthropometry, obesity, overweight

Abstract

Brazilian national data were used to compare body mass index (BMI) cutoff values proposed by Cole et al. (2000), which are based on statistical criteria of continuity to adult cutoff values, and those proposed by Must et al. (1991), which are recommended by the World Health Organization (WHO). According to the cutoff points proposed by each author, 5,736 children and adolescents were classified as of normal weight, overweight, or obese. These classifications were compared by 3 × 3 tables, and a kappa index and a confidence interval were calculated. The good concordance (kappa = 0.82) between the two cutoff values supports the hypothesis that studies on the prevalence of childhood obesity and overweight based on these two different methods can be compared. However, some differences in classification can arise when these methods are used to classify individuals. Further studies to evaluate morbidity and mortality and the classification of obesity in children and adolescents are necessary.

Introduction

Obesity is an important public health problem in developed countries and a global epidemic according to the World Health Organization (WHO). There are 150 million overweight adults, 15 million of whom are faced with the probability of premature death from diabetes as a consequence of obesity [1, 2]. Anthropometry, based on weight and height measures, is one of the commonly used methods of identifying obese people and can detect children at higher risk for nutritional or health disorders [1].

The likelihood of nutritional disorders can be diagnosed by comparing an anthropometric index with reference values [3]. Anthropometric indices are calculated from the combination of at least two basic measures: weight, height/stature, sex, and age [4]. Nowadays, body mass index (BMI) is used most often to screen for obesity. It is calculated as the weight (in kilograms) divided by the height (in meters) squared, and it was developed by Lambert Adolphe Jacques Quetelet, a Belgian mathematician, in the last century [5]. This index has been widely accepted and used in adult anthropometry, with highest and lowest limits of normality based on statistical criteria relating the higher mortality of people having higher or lower BMI than these values [1, 2, 6–9].

The use of BMI for nutritional evaluation of children and adolescents became more common after Must et al. [10, 11] published their percentile values according to age and sex, which are considered by WHO as reference values to classify adolescents as overweight and obese [1]. Since then, alternative percentile curves for children and adolescents have been proposed by several authors [3, 12–19]. However, the cutoff point values are different from those of the WHO recommendations. These values have been used to classify children and adolescents as obese and overweight. This complicates the comparison of obesity prevalence and mortality. In addition, small variations of BMI values can lead to great differences in nutritional evaluation [20], and there is a tendency to use statistical criteria and continuity for adult BMI values to define obesity and overweight in childhood and adolescence [1, 12, 13, 15, 19–24]. Cole et al. [19] have proposed BMI cutoff points different from those recommended by WHO and have pointed out this actual tendency. Therefore, there is a need to evaluate the correlation between the BMI cutoff values proposed by Cole et al. [19] and those recommended by WHO for nutritional evaluation of children and adolescents [1, 2, 10, 11]. This is the objective of this article.

Marcelo Militão Abrantes is a pediatrician at the Military Hospital of Minas Gerais (HPM-MG), Brazil. Joel Alves Lamounier is an associate professor of pediatrics at the School of Medicine of the Federal University of Minas Gerais. Enrico Antônio Colosimo is an associate professor of statistics at the Federal University of Minas Gerais.

Methods

The data used in this study were taken from Life Pattern Research, a study carried out by the Brazilian Institute of Geography and Statistics (IBGE), supported by the World Bank. Interviews and questionnaires were used to gather data from families randomly selected from the North and South regions of Brazil to evaluate living conditions, demographic tendencies (migrations, fecundity, and birth aspects), access to education and health, nutrition, and anthropometry [25].

This sample consisted of 19,409 adults and children living in 5,000 houses, distributed in 554 census areas of northeast and southeast Brazil. The sample was selected through two steps: the first was a proportional selection of geographic units based on the Demographic Census of 1991, and the second was a random selection based on housing type [25]. Data from this research are available from IBGE on CD-ROM.

From this database, all of the 8,300 children and adolescents were considered, but since no weight information was available for 605 of them, these were not included in this analysis. Among the 7,695 remaining, 1,959 were less then five years and six months old. Data from these children were not analyzed, because Must et al. [10, 11] proposed BMI values only for children six years of age or more, making comparison with younger children impossible. Therefore, the data from 5,736 children and adolescents were used in this study.

The values for weight, height, and sex were taken from the main database and stored in EpiInfo, version 6.04 [26]. BMI was calculated by the formula: weight/(height)^2. Age was calculated in months as the difference between the examination date and the birth date. Because Must et al. [10, 11] proposed values at one-year intervals, the children and adolescents were assorted in groups of a complete year through 6 more or less months. So, for example, children from 9 years and 7 months of age through 10 years and 6 months of age were allocated to the 10-year-old group. The values proposed by Cole et al. [19] based on 6-month intervals could not be used in this comparison, as the data of Must et al. [10, 11] lack this definition.

A program was developed, based on EpiInfo, to classify the nutritional status of children and adolescents, grouping them by age and sex and classifying them according to the values of Must et al. [10, 11] and Cole et al. [19]. The values utilized in this study, proposed by Must et al. [10, 11] and Cole et al. [19] for overweight and obesity, are illustrated in table 1. BMI values lower than the proposed limits for overweight were considered to indicate normal weight, those equal to or higher than the proposed limit for overweight and lower than the proposed limit for obesity were considered to indicate overweight, and those equal to or higher than the proposed limit for obesity were considered to indicate obese.

For each child or adolescent, two different nutritional classifications were made, one according to the values of Cole at al. [19] and the other according to the values of Must et al. [10, 11]. They were compared by 3 × 3 tables: children and adolescents were distributed by their nutritional classification (normal weight, overweight, and obese) according to the values of Cole et al. [19] in the columns and according to the values of Must et al. [10, 11] in the rows.

The kappa index was calculated to measure agreement between these two classifications. A value of zero indicates no concordance, and a value of one indicates perfect concordance. The more the concordance, the

TABLE 1. BMI values proposed by Must et al. [10, 11] and Cole et al. [19] for overweight and obesity limits by sex and age from 6 to 20 years

Age (yr)	Overweight				Obesity			
	Male		Female		Male		Female	
	Must	Cole	Must	Cole	Must	Cole	Must	Cole
6	16.64	17.55	16.17	17.34	18.02	19.78	17.49	19.65
7	17.37	17.92	17.17	17.75	19.18	20.63	18.93	20.51
8	18.11	18.44	18.18	18.35	20.33	21.60	20.36	21.57
9	18.85	19.10	19.19	19.07	21.47	22.77	21.78	22.81
10	19.60	19.84	20.19	19.86	22.60	24.00	23.20	24.11
11	20.35	20.55	21.18	20.74	23.73	25.10	24.59	25.42
12	21.12	21.22	22.17	21.68	24.89	26.02	25.95	26.67
13	21.93	21.91	23.08	22.58	25.93	26.84	27.07	27.76
14	22.77	22.62	23.88	23.34	26.93	27.63	27.97	28.57
15	23.63	23.29	24.29	23.94	27.76	28.30	28.51	29.11
16	24.45	23.90	24.74	24.37	28.53	28.88	29.10	29.43
17	25.28	24.46	25.23	24.70	29.32	29.41	29.72	29.69
18	25.92	25.00	25.56	25.00	30.02	30.00	30.22	30.00
19	26.36	25.00	25.85	25.00	30.66	30.00	30.72	30.00
20	26.87	25.00	26.14	25.00	31.26	30.00	31.20	30.00

higher the kappa value: values less than 0.40 are considered to indicate weak concordance, values between 0.40 and 0.75 to indicate reasonable or good concordance, and those higher than 0.75 to indicate excellent concordance [27, 28]. A confidence interval of 95% was also calculated for the kappa index.

Results

Of the 5,736 individuals studied, 1,578 were children and 4,158 were adolescents. Half (50.3%) were male. The average age was 13 ± 4.25 (SD) years, and the median was 13.25 years. The prevalences of overweight and obesity were 8% and 3.2%, respectively, according to the BMI values proposed by Cole et al. [19]. According to the values of Must et al. [10, 11] the prevalences were 10% and 4.6%, respectively. The comparison of the two methods of classification for males and females combined is shown in table 2. When examined separately, the results were similar for boys and girls (tables 3 and 4). Kappa values and their respective confidence intervals are illustrated as footnotes to these tables. Although the majority of the population (86%) was classified as having normal weight by both methods, there were differences between methods in the number of individuals classified as overweight or obese. For example, 92 subjects classified as overweight according to the method of Cole et al. [19] were considered as having normal weight according to the method of Must et al. [10, 11], whereas 57 subjects were classified as overweight (table 2).

Discussion

Although BMI has often been used in nutritional evaluation, there is no consensus about cutoff values to define obesity and overweight in children and adolescents [2, 7, 29]. Moreover, classifying overweight and obesity by different criteria makes comparison of prevalence more difficult [30]. WHO recommends the use of the 85th percentile of Must et al. [1, 10, 11] as the cutoff point, but this has not received worldwide acceptance. Some authors use different percentiles [7, 15, 22, 30], and among those who use the 85th percentile, some have not used the values recommended by WHO. In addition, many published percentile curves do not have values for the 85th percentile (table 5).

Some medical associations have used percentiles other than those recommended by WHO. For example, the American Academy of Pediatrics (AAP) and the American Medical Association (AMA) recommend that adolescents with a BMI higher than the 95th percentile (or BMI > 30) should be considered overweight and referred for body composition etiologic and diagnostic evaluation. When BMI is higher than the 85th percentile and lower than the 95th percentile, the individual should be referred if he or she has high blood pressure, has psychological problems related to overweight, has had an increase in BMI of two units

TABLE 2. Comparison of nutritional status classification according to values proposed by Cole et al. [19] and Must et al. [10, 11] for children and adolescents

Must	Cole			Total
	Normal weight	Over-weight	Obesity	
Normal weight	4,921	92	0	5,013 (87%)
Overweight	57	403	2	462 (8%)
Obesity	0	78	183	261 (5%)
Total	4,978 (87%)	573 (10%)	185 (3%)	5,736

Kappa = 0.828 (0.804 – 0.848).

TABLE 3. Comparison of nutritional status classification according to values proposed by Cole et al. [19] and Must et al. [10, 11] for male children and adolescents

Must	Cole			Total
	Normal weight	Over-weight	Obesity	
Normal weight	2,502	36	0	2,538 (88%)
Overweight	33	185	0	218 (8%)
Obesity	0	40	87	127 (4%)
Total	2,535 (88%)	261 (9%)	87 (3%)	2,883

Kappa = 0.826 (0.796 – 0.856).

TABLE 4. Comparison of nutritional status classification according to values proposed by Cole et al. [19] and Must et al. [10, 11] for female children and adolescents

Must	Cole			Total
	Normal weight	Over-weight	Obesity	
Normal weight	2,419	56	0	2,475 (87%)
Overweight	24	218	2	244 (8%)
Obesity	0	28	96	124 (5%)
Total	2,443 (86%)	302 (11%)	98 (3%)	2,853

Kappa = 0.829 (0.801 – 0.857).

TABLE 5. BMI percentile, sample, and age of BMI percentile curves published by some authors

Author	Year	Sample size	Age (yr)	Calculated percentiles
Hammer et al. [12]	1991	5,679	1–19	5–10–25–50–75–90–95
Must et al. [10, 11]	1991	20,839	6–74	5–15–50–85–95
Cole et al. [13][a]	1995	30,535	0–23	0.4–2–9–25–50–75–91–98–99.6
Lindgren et al. [14][a,b]	1995	3,633	6–16[c]	3–10–25–50–75–90–97
Sichieri and Allam [15]	1996	11,419	10–17	5–10–15–25–50–75–85–90–95
Luciano et al. [16][a,b]	1997	41,869	3–19	3–10–25–50–75–90–97
Rosner et al. [17]	1998	66,772	5–17	5–15–50–75–85–95
Anjos et al. [18]	1998	16,641	0–25	3–5–15–25–50–75–85–95–97
Cole et al. [19][d]	2000	192,727	2–18	2–9–25–50–75–91–98
Kuczmarski et al. [33]	2000		2–20	3–5–10–25–50–75–85–90–95–97

a. Studies recommended by WHO [2].
b. Percentile and Z score can be calculated from BMI.
c. 6–19 years for males.
d. Percentile related to BMI of 25 and 30 at 18 years of age also calculated.

in the preceding year, or has a family history of obesity, high cholesterol, or diabetes [21]. The European Childhood Obesity Group also recommends the use of BMI by age [31]. The Canadian Task Force on the Periodic Health Examination concluded that there is no rational aspect of obesity classification in children and emphasized that even the minimal risk of catabolism caused by food restriction is not acceptable in growing children and adolescents [32].

There are some difficulties with the use of a determined percentile. The overweight and obesity prevalence is fixed, for both sexes and all ages, as 15% and 5% when the 85th and 95th percentiles are used as cutoff points [7]. Analysis of secular tendency and obesity would be prejudiced by having the prevalence fixed, since the cutoff point would be higher as the population gains weight [2]. Besides, percentile values in one population can be different from another, but the prevalence will be the same [1, 3, 17, 19].

In 1995, WHO supported the concept that the definition of obesity in children and adolescents should be related to the adult definition "because there is little frank disease during adolescence, it is particularly important to consider the degree to which adolescent anthropometry may predict risk factors or disease in adulthood" [1]. Several authors have manifested a preference for basing cutoff points on statistical criteria and continuity to the adulthood definition [12, 13, 15, 19, 21, 23, 24]. However, it has not been established whether the continuity of obesity definition from childhood to adulthood is accompanied by morbidity and mortality risks [3]. Cole et al. [19] were the first authors to present BMI cutoff values for children and adolescents related to adult BMI.

The difficulty of establishing a consensual criterion for a superior limit of normality in children and adolescents has been cited: "The development of a consensual criterion has been limited by the lack of validity of BMI as a measure of obesity; the absence of a worldwide reference population; disagreement about what criteria are used for the cutoff point; and too few studies of sensitivity, specificity, and predictive value of obesity persistence and its complications" [22]. Furthermore, the biologic definition of what is, or is not, normal is complex, and the cutoff should distinguish a deficit that matters from one that is of no real significance [4]. Any borderline point implies mistakes and involves sensitivity and specificity concepts: once anthropometric data (weight and height) and their index have a distribution almost equal to a Gaussian curve, when the threshold chosen to distinguish normal weight from a nutritional disorder is closer to the central point of normal distribution, sensitivity will be improved despite specificity. When the opposite occurs, the threshold is far from the central point, and the specificity will be higher than the sensitivity.

Although the BMI values proposed by Cole et al. [19] are related to the cutoff point in adulthood and are based on statistical criteria, they have not yet proved their capacity for predicting morbidity and mortality in childhood, adolescence, or adulthood [3]. However, the values of Cole et al. [19] have more positive aspects than those of Must et al. [10, 11]. They cover children from two to six years of age; their values are presented for each six months and are based on a larger sample from six different countries.

The good concordance between the values proposed by Cole et al. [19] and by Must et al. [10, 11] for the nutritional classification of Brazilian children and adolescents, measured by kappa index, supports the use of both values. Therefore, population studies of prevalence based on these references can be compared.

It should be emphasized that "the use and interpretation of growth measurements may differ significantly according to whether they concern the individual (for clinical purposes) or an entire population (for public health purposes)" [1]. Despite the good concordance between the BMI values proposed by Cole et al. and

Must et al. some individuals would be "misclassified" by one author. For example, in table 2, it can be seen that 92 individuals would be classified as having normal weight by Must et al., but as overweight by Cole et al. Similarly, 78 individuals who would be classified as having normal weight by Must et al. would be classified as overweight by Cole et al. These differences for individual subject classifications are important for future studies that seek to determine whether certain chosen cutoff limits are linked with morbidity and mortality endpoints, which would rely on values for individuals.

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Dietary and physical activity patterns of 8- to 10-year-old urban schoolchildren in Manila, Philippines

Rodolfo F. Florentino, Gracia M. Villavieja, and Ruby D. Laña

Key words: Nutritional status, nutrition transition, child overweight, child activity, nutrition education

Abstract

This report is the second part of a study on the nutrition of urban schoolchildren in the city of Manila; the first part was on nutritional status. The primary purpose of the study was to gather data that will assist authorities in planning and implementing nutrition education programs focused on the growing problem of obesity and overweight in children. The study included 1,208 children 8 to 10 years of age, who were randomly selected from all public and private schools in the city of Manila. Data on the children's dietary and physical activity patterns, together with information on nutrition-related knowledge, attitudes, and preferences of the children and their parents, were gathered by interviews and self-administered questionnaires. There were distinct differences in dietary and physical activity patterns between the two groups of children. Children from private schools, who are generally of higher socioeconomic status than those from public schools, tended to consume more total food, more animal foods, fats, and oils, and more beverages, resulting in higher intakes of calories, protein, iron, and vitamin A than public schoolchildren. Moreover, children from private schools were apparently less physically active, were more likely to be driven to school instead of walking, and were more likely to prefer television and computer games over outdoor games. These differences agree with an earlier report on the nutritional status of the children as determined by anthropometry, which showed a higher proportion of overnutrition and a lower proportion of undernutrition among private schoolchildren than among public schoolchildren. Although the emphasis in public schools should be on prevention and control of undernutrition in children, private schools should begin to look at the emerging problem of overnutrition and the role of physical activity programs in the health of children. The information on the knowledge, attitudes, and preferences of the children and their parents showed that parents or guardians, teachers, and television influence the nutritional practices of schoolchildren. These groups should therefore be the major targets for nutrition education programs meant to improve the nutrition and health of schoolchildren.

Introduction

The increasing problem of overweight and obesity in children has been observed in countries in social and economic transition. In the Philippines, national nutrition surveys showed an increasing trend in the prevalence of overweight among schoolchildren in the last decade: from 5.7% (> 95th percentile for local weight-for-age standards) in 1989–1990 [1] to 8.0% in 1993 [2], and to 8.8% in 1996 [3]. In the highly urbanized city of Metro Manila, the prevalence was even higher than the national average and has increased more rapidly, from 9.7% in 1989–1990 to 16.3% in 1996.

To delve deeper into the problem of overweight and obesity in children, the International Life Sciences Institute Southeast Asia organized a three-country study of 8-to-10-year-old schoolchildren in urban areas of Malaysia, Indonesia, and the Philippines [4–6]. Using similar methods, the studies examined the children's nutritional status and their dietary and physical activity patterns. The ultimate purpose of the study was to gather data that will assist authorities in planning and implementing nutrition education programs for the improvement of nutrition among schoolchildren. The study in the Philippines covered public and private schools in Manila where, in general, children who attend the government-run public schools are of lower

The authors are affiliated with the Food and Nutrition Research Institute, Department of Science and Technology, in Manila, Philippines

socioeconomic status than those in private schools. An earlier report on the nutritional status of the children showed clearly that children in private schools had a much lower prevalence of undernutrition and a much higher prevalence of overweight and obesity than those in public schools [3]. This report attempts to determine the influence of diet and physical activity on the children's nutritional status, particularly with respect to overweight and obesity.

Methods

Sampling design and coverage

Schoolchildren aged 8 to 10 years from the city of Manila were included in the study. A two-stage stratified sampling design was employed covering all public and private schools in the city. Stratification was performed according to type of school (public or private), age level, and sex. The first stage involved the selection of schools, and the second stage involved the selection of subjects. A more detailed description of the sampling design and coverage was presented in an earlier report on the nutritional status of the children [6].

Data collection

Pretested questionnaires were used to interview the children to obtain information on their dietary and physical activity patterns and their nutritional knowledge, attitudes, and practices (KAP). Information on dietary patterns was obtained from a record of the actual food and beverages consumed by the child over three days, according to the kind or type of item, its description, and the household measure and/or amount of the food. The intake included foods eaten for breakfast, lunch, supper, and snacks. Three food records were completed by each child, with the help of the parents, if necessary. The interviewers reviewed the records the following day for completeness and clarification. For food items whose weights and sizes could not be ascertained from the interview, market surveys were conducted by the interviewers to obtain the needed information.

Information on the activity patterns of the children and their KAP on physical activity and nutrition were also obtained by self-administered structured questionnaires that were completed by each child at home, with the help of the parents if necessary. At the same time, the parents were asked to fill out a form to indicate their own knowledge of and attitudes toward their child's physical activity at home and in school, as well as the importance of food and nutrition for the child's health. Again, the interviewers reviewed the forms for completeness and clarification.

Editing and processing of data

The data collected were edited both in the field and in the office, after which master databases were produced. The food records were subjected to the Individual Dietary Evaluation System (IDES), a computer software program used in the evaluation of food-composition data for individuals [7]. This system computes the nutrient requirements of subjects using the latest revision of the Recommended Dietary Allowances (RDA) of Filipinos [8], converts food items into a common state (i.e., as purchased or after preparation for consumption), and computes the intake of 11 nutrients in terms of amount and percentage adequacy as compared with the RDA. In deriving the nutritive values of the food items, the Philippine Food Composition Tables (FCT), complemented by foreign FCTs, were used [9].

The master data files of the various survey forms were used as inputs to generate the necessary tables using the Statistical Package for Social Sciences (SPSS) for Windows Release 5.0 [10].

Results

The survey included 1,208 schoolchildren, 642 from public schools and 566 from private schools, more or less equally distributed between boys and girls and among the three age groups (8, 9, and 10 years).

TABLE 1. Selected food items most commonly consumed by children from public and private schools[a]

	Public schools		Private schools	
Food item	%	Frequency	%	Frequency
Rice	100.0	2.4	99.8	2.6
Cooking oil	94.2	1.1	95.9	1.2
Bread (*pan de sal*)	71.6	0.8	52.1	0.6
Bread (*pan americano*)	60.7	0.9	59.5	0.9
Instant noodles	68.5	0.8	58.3	0.7
Chicken (eggs	76.0	0.7	65.6	0.6
Chicken (thigh meat)	23.3	0.5	40.8	0.6
Hot dog	53.6	0.6	70.9	0.8
Beef	34.7	0.5	55.1	0.6
Milkfish	47.6	0.6	34.6	0.5
Tilapia fish	30.0	0.5	29.4	0.5
Pork	24.5	0.5	27.1	0.5
Soft drinks	22.1	0.5	37.8	0.6

a. The percentage of subjects consuming the item and the number of times the item is consumed per day (frequency) are given.

Dietary pattern

The kind of food items commonly consumed by the children from public and private schools were similar, but the percentage of children consuming different food items differed between the two groups of children (table 1). Thus, practically all children ate rice two or three times a day, and about 95% of them used cooking oil daily. About 60% ate loaf bread (*pan americano),* whereas more public schoolchildren ate the local bread (*pan de sal*). More children from public schools consumed instant noodles and fish, but more from private schools ate other animal foods, such as chicken (except for chicken eggs), hot dogs, beef, and pork. More children from private schools consumed soft drinks.

The mean one-day food consumption of the children according to type of school is shown in table 2. The children from private schools consumed 24% more food than did those from public schools. The difference arose from a larger intake of food from practically all the food groups, especially meat and meat products (twice the intake of those from public schools), poultry (34% higher), milk and milk products (73% higher), starchy roots and tubers (75% higher), fats and oils (21% higher), beverages (11% higher), and fruits (9% higher). Translated to nutrient intake, the higher food consumption by children in private schools resulted in a higher total energy intake arising from the higher fat and protein consumption (table 3). The total energy intake of the children from private schools was 19% more than that of the children from public schools. Total fat intake was 37% more, and protein intake was 23% more. The fat intake of the children from private schools contributed 27% of their total caloric intake, while that of the children from public schools contributed only 14%. The intakes for the other principal nutrients were also higher among the children from private schools.

Compared with the RDA, the mean nutrient intakes of the children from private schools were generally adequate (table 3). On the other hand, the mean nutrient intakes of those from public schools were deficient

TABLE 2. Mean one-day food consumption (raw, as purchased, g) according to type of school

Food group and subgroup	Public school	Private school
Cereals and cereal products	303	319
Rice and rice products	222	231
Corn and corn products	3	5
Other cereal products	78	83
Starchy roots and tubers	8	14
Sugars and syrups	15	17
Fats and oils	14	17
Fish, meat, and poultry	217	313
Fish and fish products	69	54
Meat and meat products	81	169
Poultry	67	90
Eggs	26	22
Milk and milk products	122	211
Whole milk	55	82
Milk products	67	129
Dried beans, nuts, and seeds	8	5
Vegetables	25	25
Green leafy and yellow	7	9
Other	18	16
Fruits	111	121
Vitamin C–rich	38	48
Other	73	73
Miscellaneous	67	74
Beverages	65	72
Condiments and others	2	2
Total	916	1,138

TABLE 3. Mean one-day per capita nutrient intake and percent adequacy among schoolchildren according to type of school

Nutrient	Public school	Private school
Energy		
Intake (kcal)	1,817	2,168
% adequacy	101.0	118.8
Protein		
Intake (g)	63.2	77.7
% adequacy	161.6	199.2
Iron		
Intake (mg)	11.9	13.1
% adequacy	88.1	97.0
Calcium		
Intake (g)	0.63	0.58
% adequacy	73.0	92.1
Retinol equivalents		
Intake (μg)	485.6	586.8
% adequacy	120.1	145.3
Thiamin		
Intake (mg)	1.32	1.41
% adequacy	141.9	151.6
Riboflavin		
Intake (mg)	0.78	0.99
% adequacy	83.9	106.1
Niacin		
Intake (mg)	19.0	22.4
% adequacy	107.3	127.3
Ascorbic acid		
Intake (mg)	69.4	89.6
% adequacy	117.0	151.4
Fats		
Intake (g)	47.8	65.7
Carbohydrates		
Intake (g)	287.0	311.2

in iron, calcium, and riboflavin and were at best just above 100% of the RDA for energy.

Figure 1 shows the distribution of energy intakes of the children in terms of percentage of the RDA. The difference in distribution between the two sets of subjects is obvious. Only 31% of the children from private schools consumed less than 100% of the RDA, as compared with 55% of the children from public schools. On the other hand, 17.3% of the private schoolchildren consumed more than 150% of the RDA, as compared with only 7.4% of the public schoolchildren.

Physical activity pattern

Table 4 shows the percentage distribution of the children according to type of activity. Outdoor activities during physical education were more common among private than among public schoolchildren (61.3% vs. 26.7%), whereas calisthenics or exercise was more common among public schoolchildren (58.4% vs. 25.8%). About half of the public schoolchildren walked to school (49.8%), whereas 87.5% of private schoolchildren rode to school. More private than public schoolchildren ate lunch at school (24.2% vs. 2.8%).

Table 5 shows the average time spent by the children on selected activities. Although the children from both types of school spent about the same amount of time sleeping (9 hours) and watching television (106 minutes), those from private schools spent more time commuting (by an average of 13 minutes), doing homework (by an average of 22 minutes), and playing indoor games (by an average of 5 minutes). On the other hand, children from public schools spent more time doing household chores (by an average of 11 minutes) and playing outdoor games (by an average of 7 minutes).

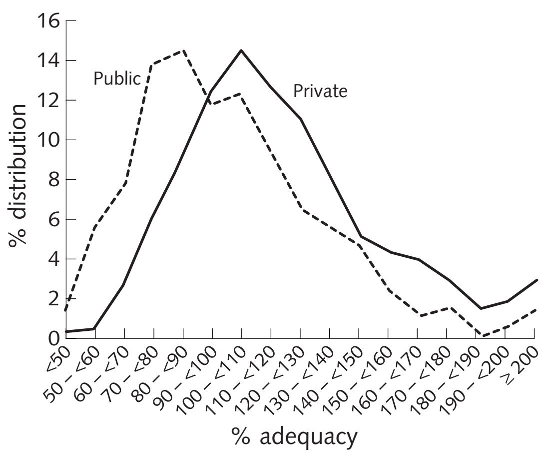

FIG. 1. Percentage distribution of schoolchildren according to adequacy of energy intake and type of school

Nutrition-related attitudes, practices, and perceptions of children

Table 6 compares the results of the interviews with public and private schoolchildren with respect to their attitudes, practices, and perceptions related to nutrition and physical activity. More private schoolchildren thought they were fat and wanted to be thinner, whereas more public schoolchildren thought they were thin and wanted to be fatter. The private schoolchildren had more pocket money, spending most of it on food, and they ate snacks more frequently. Both public and private schoolchildren had correct perceptions about foods that are good or bad for them. With regard to physical activity, more private schoolchildren preferred to watch television and play computer games, whereas more of the public schoolchildren preferred sports and outdoor games. Only a fifth to a fourth of the public and private schoolchildren said they exercised every day, most claiming they were too busy or lazy to do so, but three-fourths of the children considered exercise to be very important. Both groups of children ranked parents and siblings first in terms of who or what exerted the greatest influence on their eating patterns, followed by teachers and television.

TABLE 4. Percentage distribution of schoolchildren according to type of activity and school

Activity	Public school	Private school
Physical education at least once a week	91.4	95.9
Outdoor activities during physical education	26.7	61.3
Calisthenics or exercises during physical education	58.4	25.8
Walk to school	49.8	9.0
Ride in vehicle to school	43.6	87.5
Get up before 6:00 a.m.	46.0	49.3
Go to bed after 10:00 p.m.	18.9	20.7
Less than 8 h sleep	12.7	13.8
Eat lunch in school	2.8	24.2

TABLE 5. Average daily time spent in selected activities according to type of school

Activity	Public school	Private school
Sleep (h)	9.4	9.2
Traveling to school (min)	14	27
Watching television (min)	106	106
Homework (min)	52	74
Household chores (min)	39	28
Indoor games (min)	28	33
Outdoor games (min)	37	30
Other activities (min)	29	22

Nutrition-related attitudes, practices, and perceptions of parents

Table 7 compares the attitudes, practices, and perceptions of the parents of the children from public and private schools with respect to nutrition and physical activity. Parents of children from both schools considered nutritional value, the child's preference, and availability in the market when making food purchases for their children. Both groups of parents considered physical activity to be important for their child's health, although more parents of children from private schools encouraged their children to take part in physical activities. More parents of children from public schools considered a fat child to be healthy, and more preferred their children to gain weight. On other hand, more parents of children from private schools were knowledgeable about foods that are good for their children, and they exerted more influence on what their children ate at mealtimes. Most parents, however, especially parents of children from private schools, wanted to improve the meal patterns of the family to achieve better health for their children.

Discussion

The method used to obtain the dietary and physical activity patterns of the children was limited by the fact that it required judgment on the part of the subjects about the kinds of foods they usually consume and the physical activities they usually perform, as well as by the accuracy of recording their food intake for three days. Thus, in order to minimize errors and omissions, the interviewers carefully reviewed the children's responses the day following their recording. Moreover, comparing the responses of the two groups of children rather than inferring conclusions based on the absolute responses and quantitative measurements would minimize biases arising from errors in judgment, recording, and quantitative estimations.

The kinds of foods the two groups of children

TABLE 6. Percentage distribution of children according to their nutritional attitudes, practices, and perceptions

Attitude, practice, or perception	Public school	Private school
He/she is fat	16.3	20.4
He/she is thin	44.2	33.1
He/she wants to be thinner	3.8	12.2
He/she wants to be fatter	67.3	40.4
Pocket money < P10.00	14.2	59.6
Food as expense item	90.2	83.7
Perceived as no. 1 good food	Vegetables, fruits Fish and meat	Vegetables, fruits Fish and meat
Perceived as no. 1 bad food	Junk food, candies	Junk food, candies
Source of nutritional information		
Mother/father/guardian	77.2	88.3
Teacher	48.0	52.7
Television	18.6	25.3
Eats breakfast every day	84.8	81.6
Eats 2 or more snacks a day	58.1	69.0
Type of recreational activity		
Watching television	37.5	40.9
Reading	25.9	16.6
Playing computer games	5.5	10.1
Sports and outdoor games	24.5	20.9
Exercise every day	20.9	25.5
Walking or jogging	27.7	23.2
Basketball	24.5	32.0
Cycling	12.8	11.2
Main reason for not exercising		
Busy	24.1	15.0
Lazy	12.5	11.0
Thinks exercise as very important	73.0	73.5
Factors influencing eating pattern	Parents, siblings, teachers, television	Parents, siblings, teachers, television

TABLE 7. Percentage distribution of parents according to their knowledge, attitudes, and perception of food and nutrition and physical activity

Knowledge, attitude, or perception	Public school	Private school
Factors considered in making food purchases	Nutritional value, child's preference, availability	Nutritional value, child's preference, availability
Considers physical activity very important to child's health	79.2	80.7
Always encourages child to take part in physical activity	51.6	66.1
Considers breakfast very important for child	89.3	91.4
Thinks that a fat child is healthy	44.6	20.7
Thinks that a fat child is not healthy	44.5	61.4
Thinks child is fat	21.6	24.6
Prefers child to gain weight	83.4	66.1
Very interested in learning more about nutrition	58.2	60.0
Knowledge of food good for child	89.7	97.5
Decides what child is to eat at mealtime	59.9	70.2
Child always eats snacks between meals	62.8	57.0
Influences how child spends pocket money	26.3	28.8
Would definitely change family meal pattern for better health	61.0	75.9

consumed were similar, but the children from private schools consumed more animal products, such as beef, chicken, and milk, as well as more fats and oils and beverages. This pattern, together with the larger amount of food they consumed, translated into higher intakes of calories, protein, iron, vitamin A, and fat. These data agree with the nutritional status of the children based on anthropometric measurements [6]. Children from private schools had a greater mean height and weight and a lower frequency of stunting, underweight, and thinness than those from public schools. On the other hand, the proportion of overweight children was higher in private schools than in public schools.

Children from private schools were less physically active than public schoolchildren. Private schoolchildren were more likely to ride to school and spent more time doing homework and playing indoor games than public schoolchildren (although they spent about the same amount of time watching television). In contrast, children from public schools were more likely to walk to school, were more likely to do calisthenics or exercise during physical education class, and spent more time doing household chores, playing outdoors, and performing other physical activities.

Private schoolchildren had less opportunity for physical activity than public schoolchildren. They had more pocket money for school, and most of this was spent on food. They spent more time riding to school. More private schoolchildren than public schoolchildren ate snacks two or more times a day and preferred watching television and playing computer games. There was no difference between the two groups of children in terms of nutritional knowledge and the value of physical exercise. Both groups received nutritional information from their parents or guardians, teachers, and television, in that order.

The parents of both groups of children considered proper nutrition and sufficient physical activity to be important to their children's health. However, the parents of private schoolchildren were more knowledgeable about nutrition and nutritious foods, exerted more influence on what their children ate, and were more aware of their children's level of physical activity.

The study data indicate that public schools should emphasize prevention and control of undernutrition in children and that private schools should begin to look at the emerging problem of overnutrition and the role of physical activity programs in the health of children. The information on the knowledge, attitudes, and preferences of children and parents showed the important role of parents and guardians, teachers, and television in influencing the nutrition of schoolchildren. Thus, these groups should be the major focus for nutrition education programs meant to improve the nutrition and health practices of schoolchildren.

Summary and conclusions

This study of 1,208 public and private schoolchildren in Manila revealed distinctly different dietary and physical activity patterns in the two groups, which were reflected by their nutritional status. Children from private schools, who are generally of higher socioeconomic status, tended to consume more total food and more animal foods, fats and oils, and beverages, resulting in higher intakes of calories, protein, iron, and vitamin A than children from public schools. Moreover, children from private schools were less physically active, were more likely to be driven to school, and preferred television and computer games to outdoor games. These differences agree with an earlier report on the nutritional status of the children as determined by anthropometry, which showed a higher proportion of overnutrition and a lower proportion of undernutrition among private schoolchildren than public schoolchildren.

Whereas the emphasis in public schools should be on the prevention and control of undernutrition in children, private schools should begin to look at the emerging problem of overnutrition and the role of physical activity programs in the health of children. The information on nutrition-related knowledge, attitudes, and preferences of children and parents showed the important role of parents and guardians, teachers, and television in influencing the nutritional practices of schoolchildren. Thus, these groups should be the major targets for nutrition education programs meant to improve the nutrition and health of schoolchildren.

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Measurement of energy cost of selected household and farm activities performed by rural women

Kiran Bains, Balwinder Kaur, and S. K. Mann

Key words: India, energy expenditure, physical activity, rural women

Editorial comment

Nutritionists and physiologists owe a great debt to the many investigators in various parts of the world who have undertaken the laborious direct measurement of oxygen consumption for various activities using a portable calorimeter. These have been compiled by the Food and Agriculture Organization/World Health Organization/ United Nations University (FAO/WHO/UNU) [1] and are currently being updated. The energy cost of activities compiled by this method can then be used to calculate the total energy cost in various ways. The most common is a timed record of activities that can be multiplied by the average total duration of categories of activities with similar energy cost.

The various methods for evaluating the energy expenditure of specific activities have been reviewed by the International Dietary Energy Consultative Group (IDECG) [2]. Doubly labeled isotope methods give the estimated total energy expenditure over several days but are not applicable to individual activities. Electronic measurement of heart rate calibrated against measurement of oxygen consumption at various heart rates has been reasonably valid.

Another approach to the intensity of various activities has been the use of an accelerometer about the size of a pocket watch, either mechanical or electronic. The results must be calibrated against data from direct measurement. The Caltrac accelerometer used in the study that follows takes this method a step further by automating the calculations. However, as the authors conclude, like other indirect methods, it must be calibrated against data from direct measurements of energy expenditure.

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Abstract

A nutritional study was carried out on 30 rural, low-income women, aged 25 to 35 years, in the village of Dhandra, Ludhiana District, Punjab, India, to measure the energy cost of selected household and farm activities. The mean weight, mid-upper-arm circumference, and triceps skinfold thickness were below the reference standards. A negative energy balance among the subjects indicated their poor energy status. The energy costs of selected household and farm activities were assessed by the Caltrac personal activity computer. The energy costs of household activities—making dough, making chapatis, grinding masala, hand pumping, washing utensils, sweeping, mopping, washing the floor, mud pasting, and washing clothes—were 0.0306. 0.0281, 0.0595, 0.0337, 0.0266, 0.0424, 0.0530, 0.0331, 0.0634, and 0.0453 kcal/kg/min, respectively. The energy costs of farm activities— collecting fodder, chaffing fodder, milking, making dung cakes, picking sag, harvesting wheat, bundling wheat, picking paddy, brooming paddy, and separating paddy—were 0.0472, 0.0372, 0.0530, 0.0270, 0.0337, 0.0623, 0.0374,

The authors are affiliated with the Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, in Ludhiana, Punjab, India.

0.0411, 0.0370, and 0.0744 kcal/kg/min, respectively. All selected activities were categorized as light, except for grinding masala, mopping, mud pasting, harvesting wheat, separating paddy, and milking, which were categorized as moderate on the basis of Food and Agriculture Organization (FAO) physical activity ratios. The Caltrac gave lower values for the energy costs of most of the activities. Although it is simpler and less costly, the Caltrec must be calibrated against methods of measuring oxygen consumption for similar activities.

Introduction

Energy is the basic requirement for the maintenance of life and physical work output. The energy expenditure of a person is related to several factors, the major ones being physical activity, body mass and composition, temperature, and recent food intake. Other factors, such as age and sex, are related to energy expenditure, but their effects are secondary [1]. The maintenance of body energy balance depends on the relationship between energy intake and expenditure. Restricted energy intake leads to a reduction in energy expenditure, which may appear in the form of decreased metabolic rate and limited work capacity. The energy intake further depends upon income, which is the major deciding factor that determines the quantity and quality of the diet. Adequate energy status of young women is of vital importance because they have to perform multiple roles. Women are engaged in routine and occupational activities both at home and outside that require light to heavy expenditure of energy. Rural women spend excessive time and energy on routine domestic chores and agricultural activities, and this has adversely affected the nutritional status and health of most of the rural population. In addition, the economic status of these women differs widely, which further affects their work performance and health [2]. The assessment of energy expenditure is, therefore, a more logical approach to determine the energy requirement in terms of output for productive work and leisure activity.

The physical activity diary method (PADM) is a common technique used to estimate total daily energy expenditure. This procedure is tedious and time-consuming. Caltrac is an electronic device developed to estimate the energy cost of different activities that is easy to use under field conditions. It showed high test–retest reliability during laboratory tests [3–5]. The measurement of energy expenditure to determine energy requirement is of great significance. The present study, therefore, was designed to measure the energy cost of common household and farm activities performed by Punjabi farm women.

Materials and methods

Thirty nonpregnant, nonlactating women, aged 25 to 35 years, were selected from the village of Dhandra, Ludhiana District, India, to participate in the study. All were in the low-income group, with a per capita monthly income below Rs 400 (about US$8.70).

The height, weight, mid-upper-arm circumference (MUAC), and triceps skinfold thickness (TSFT) of the subjects were measured [6]. Body mass index (BMI) was calculated by the equation given by Garrow [7], and body fat percentage was estimated from the skinfold thickness at four sites (biceps, triceps, subscapular, and suprailiac) by the equation given by Durnin and Womersley [8].

Food intake was recorded for seven consecutive days by the 24-hour recall method. Nutrient intake was calculated with the MSU Nutriguide computer program [9] for the Indian population. Total daily energy expenditure was estimated by the physical activity diary method (PADM). The time spent on daily activities of the subjects was recorded in 15-minute intervals for seven days along with the dietary survey. Energy expenditure was calculated by applying the energy cost of each activity as given by James and Schofield [10]. The basal metabolic rate (24 hours) was calculated by the following prediction equations from the Indian Council of Medical Research (ICMR) [11]:

$$\text{18–30 years: } 14.0 \times \text{body weight (kg)} + 471$$
$$\text{30–60 years: } 8.3 \times \text{body weight (kg)} + 788$$

The physical activity level (PAL) was calculated as:

$$\text{Physical activity level} = \frac{\text{Total energy required over 24 hours}}{\text{Basal metabolic rate over 24 hours}}$$

The total daily energy expenditure was also calculated from the ICMR prediction equation where the basal metabolic rate (BMR) factor of 1.9 was given for moderately active women [11].

Ten household activities (making dough, making chapatis, grinding masala, hand pumping, washing utensils, sweeping, mopping, washing floors, mud pasting, and washing clothes) and five daily farm activities related to dairy operations (collecting fodder, chaffing fodder, milking, making dung cakes, and picking sag) were selected randomly from the daily energy expenditure pattern of the subjects to assess their energy cost. In Punjab most of the farm operations are carried out by men. Women from low-income families engage in farm activities during the wheat and paddy harvesting seasons. Therefore, all the farm activities during harvesting were selected. These included harvesting wheat, bundling wheat, picking paddy, brooming paddy, and separating paddy. All of the household and farm activities were performed manually by the subjects.

The energy cost of individual activities was determined by the Caltrac Personal Activity Computer. The weight (pounds), height (inches), age (years), and sex of the subjects was entered into the computer. The Caltrac calculates the basal metabolic energy being used by the body immediately after the personal data are entered. It estimates the total energy expenditure from activity counts and the estimated basal metabolic rate along with an estimate for the thermic effect of feeding. The counts are accelerometry measurements of the body's movement in a vertical plane [12]. The energy cost of all the activities was determined three times. The physical activity ratios (PARs) of individual activities were calculated by the following formula [10]:

$$PAR = \frac{\text{Energy cost of an activity per minute}}{\text{Energy cost of basal metabolic rate per minute}}$$

Results and discussion

Anthropometry

The subjects were taller (152.3 cm) than the average Indian woman (150.7 cm) [11]. On the other hand, the body weights of the subjects were less than the standards of weight-for-height (52–58 kg) [13]. The MUAC and TSFT were 83% and 74% of the reference standards, respectively [6]. The BMI was in the normal range (20.0–25.0 kg/m^2) but toward the lower margin [7], whereas the percentage of body fat was in the normal range [8].

Energy balance

The daily energy intake of the subjects was 1,661 kcal, which was 75% of the recommended dietary allowance (RDA) of the ICMR [10]. The estimated total daily energy expenditure of the subjects was 2,067 according to the physical activity diary method and 2,251 kcal according to the ICMR prediction equations (table 1). The physical activity level (PAL) of the subjects ranged between 1.43 and 2.08, with a mean value of 1.74. Spurr et al. [2] estimated the PAL of farm women as 1.83 when at home and 1.90 when at work. The anthropometric profile and energy balance of the subjects indicated an unsatisfactory energy balance. Mann et al. [14] also reported a poor energy status for rural women belonging to low-income families.

Daily energy expenditure pattern

The daily household and farm activities performed by the subjects were classified on the basis of the Food and Agriculture Organization (FAO) physical activity ratios [10]. The subjects spent an average of 9 hours and 19 minutes performing light household activities and 2 hours and 50 minutes in moderate activities. On the other hand, those subjects who owned milk animals spent an average of 3 hours and 31 minutes daily on dairy-related activities (table 2).

The farm activities for the *kharif* (April) crop included wheat harvesting and bundling, which lasted for 15 days. The total average daily time spent on farm activities was 9 hours and 22 minutes. During the *rabi* season (September-October), picking and brooming paddy took 8 to 10 days and paddy separation lasted for 10 to 12 days. The total daily time spent on farm activities during the *rabi* season was 7 hours (table 3).

Energy cost and physical activity ratio of household activities

Table 4 shows the energy cost and physical activity ratio (PAR) of selected household activities (making dough, making chapatis, grinding masala, hand pumping, washing utensils, sweeping, mopping, washing floors, mud pasting, and washing clothes) assessed by

TABLE 1. Anthropometric measurements, energy intake, total daily energy expenditure, and energy balance of the subjects

Measurement	Range	Mean ± SEM
Anthropometric measurements		
Height (cm)	140.0 to 171.0	158.0 ± 1.4
Weight (kg)	42.0 to 57.0	49.9 ± 0.7
Mid-upper-arm circumference (cm)	21.0 to 27.0	23.6 ± 0.3
Triceps skinfold thickness (mm)	5.00 to 16.00	12.23 ± 0.45
Body mass index (kg/m^2)	17.5 to 23.5	20.1 ± 0.30
Body fat (%)	19.7 to 29.1	26.8 ± 0.40
Energy intake (kcal/day)	1,460 to 1,942	1,661 ± 26
Basal metabolic rate	1,059 to 1,269	1,191 ± 9
Total daily energy expenditure (kcal/day)		
Physical activity diary method	1,553 to 2,446	2,067 ± 44
Physical activity level (PAL)	1.43 to 2.08	1.74 ± 0.03
ICMR prediction method	2,012 to 2,385	2,251 ± 18
Energy balance (kcal/day)		
Physical activity diary method	–258 to –941	–590 ± 34
ICMR prediction equation	78 to –796	–406 ± 44

Caltrac. The energy costs of all household activities were lower than the BMR multiples of FAO, except for mopping and washing the floor (fig. 1). A low energy expenditure estimated by Caltrac has also been reported in the literature [15–18]. The higher energy costs of mopping and washing floors could be due to different procedures in performing these activities by the subjects when compared to the population group described in the FAO study [10]. The energy costs of hand pumping and mud pasting or of similar activities were not available in the literature for comparison. The classification of activities based on the physical activity ratio [10] is shown in table 5. The physical activity ratio of the household activities ranged from 1.30 to 3.09. The minimum physical activity ratio was observed in case of washing utensils (1.30) followed by making chapatis (1.37), while the maximum PAR was found in mud pasting (3.09) followed by grinding masala (2.90) and mopping (2.58). According to the classification of activities on the basis of FAO physical activity ratios [10], all the household activities were categorized as light with a PAR ranging from 1.0 to 2.5 except for grinding masala, mopping, and mud pasting which were in the moderate category (2.6 to 3.9). None of the household activities were observed as heavy.

TABLE 2. Daily energy expenditure pattern of the subjects (n = 30)

Activity (PAR)[10]	Time spent (h.min)	
	Range	Mean ± SEM
Sleep (1.0)	7.30–10.00	8.49 ± 0.06
Household activities (n=30)		
Group I (1.2)		
Sitting, recreation, watching television	1.30–6.00	2.53 ± 0.15
Group II (1.6)		
Eating meals, soaking clothes, cutting vegetables, smearing chapatis, self-care, walking, serving meals, going outside for toilet	1.45–3.15	2.29 ± 0.04
Group III (2.1)		
Arranging house, making tea, making chapatis, preparing vegetables, dishwashing, child care	2.30–6.45	4.37 ± 0.14
Group IV (2.8)		
Sweeping, hand pumping, cutting sag, mixing sag	0.30–4.15	1.30 ± 0.11
Group V (3.8)		
Mopping, washing clothes and floor, kneading dough, picking sag	0.30–2.00	1.20 ± 0.05
Farm activities, n=16		
Group I (2.8)		
Chaffing fodder, feeding cattle	0.30–1.30	1.20 ± 0.05
Group II (3.8)		
Removing cow dung, milking, collecting fodder	1.15–5.30	3.31 ± 0.19

TABLE 3. Time spent daily on seasonal farm activities by the subjects (n=30)

Activity	Period (days)	Mean ± SEM (h.min)
Kharif (Apr)		
Harvesting wheat	15	8.17 ± 0.23
Bundling wheat	15	1.05 ± 0.05
Total		9.22
Rabi (Sep-Oct)		
Picking paddy	8–10	4.47 ± 0.14
Brooming paddy	8–10	1.09 ± 0.17
Separating paddy	10-12	1.04 ± 0.04
Total		7.00

Energy cost and physical activity ratio of farm activities

The energy cost and physical activity ratio (PAR) of selected farm activities—collecting fodder, chaffing fodder, milking, making dung cakes, picking sag, harvesting wheat, bundling wheat, picking paddy,

TABLE 4. Energy cost and PAR of household and farm activities estimated by the Caltrac Personal Activity Computer (mean ± SD) (n=30)

Activity	Energy cost (kcal/kg/min)	PAR
Household activities		
Making dough	0.0306 ± 0.0004	1.48 ± 0.02
Making chapatis	0.0281 ± 0.0003	1.37 ± 0.01
Grinding masala	0.0595 ± 0.0005	2.90 ± 0.02
Hand pumping	0.0337 ± 0.0005	1.64 ± 0.02
Washing utensils	0.0266 ± 0.0002	1.30 ± 0.01
Sweeping	0.0424 ± 0.0005	2.06 ± 0.02
Mopping	0.0530 ± 0.0005	2.58 ± 0.02
Washing floors	0.0331 ± 0.0004	1.61 ± 0.02
Mud pasting	0.0634 ± 0.0005	3.09 ± 0.02
Washing clothes	0.0453 ± 0.0003	2.21 ± 0.02
Farm activities		
Collecting fodder	0.0472 ± 0.0004	2.32 ± 0.03
Chaffing fodder	0.0372 ± 0.0005	1.81 ± 0.02
Milking	0.0530 ± 0.0003	2.58 ± 0.02
Making dung cakes	0.0270 ± 0.0005	1.30 ± 0.03
Picking sag	0.0377 ± 0.0002	1.84 ± 0.05
Harvesting wheat	0.0623 ± 0.0005	3.03 ± 0.02
Bundling wheat	0.0374 ± 0.0004	1.82 ± 0.02
Picking paddy	0.0411 ± 0.0008	2.01 ± 0.05
Brooming paddy	0.0370 ± 0.0001	1.80 ± 0.05
Separating paddy	0.0744 ± 0.0005	3.62 ± 0.02

brooming paddy, and separating paddy—were assessed by Caltrac (table 4). Caltrac gave higher energy costs for picking sag and lower ones for collecting fodder, milking, and making dung cakes (fig. 2) than FAO. The energy cost estimated by Caltrac was higher for seasonal farm activities such as picking paddy, brooming paddy, and separating paddy compared with the values for similar activities given by FAO. The energy costs of the same activities were not available for comparison, so similar activities were used. The higher energy costs for these activities could be due to the different procedures used in performing these activities by the subjects of the present study when compared to the population in the FAO study. The energy costs of bundling wheat and chaffing fodder or similar activities were not available in the literature for comparison.

The PAR estimated by Caltrac was highest for separating paddy (3.62), followed by harvesting wheat

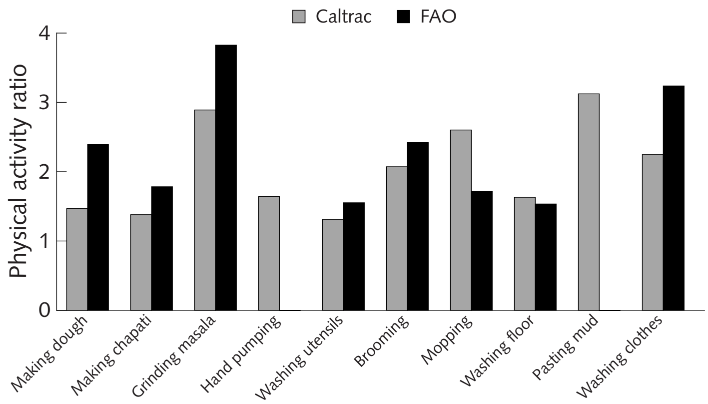
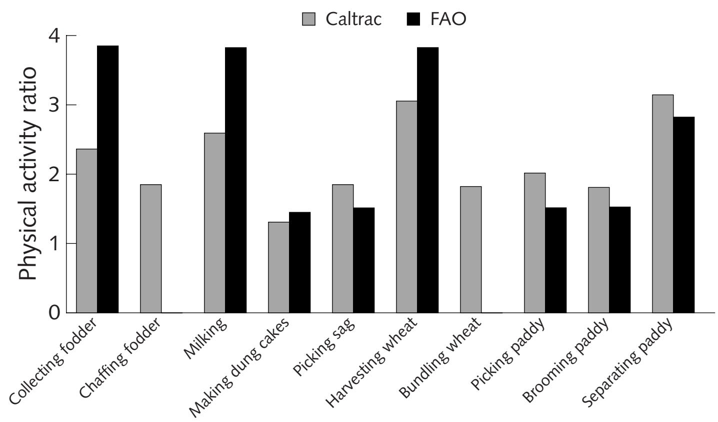


FIG. 1. Comparison of PAR of household activities estimated by Caltrac and FAO [10] BMR multiples



IG. 2. Comparison of PAR of farm activities estimated by Caltrac and FAO [10] BMR multiples

TABLE 5. Classification of selected household and farm activities on the basis of PAR estimated by the Caltrac Personal Activity Computer

PAR	Category	Activity
1.0-2.5	Light	*Household activities:* making dough, making chapatis, hand pumping, washing utensils, sweeping, washing floors, washing clothes *Farm activities:* collecting fodder, chaffing fodder, making dung cakes, picking sag, bundling wheat, picking paddy, brooming paddy
2.6-3.9	Moderate	*Household activities:* grinding masala, mopping, mud pasting *Farm activities:* milking, harvesting wheat, separating paddy
4.0	Heavy	—

(3.03), and it was lowest for making dung cakes (1.30), followed by brooming paddy (1.80) and chaffing fodder (1.81). Collecting fodder, chaffing fodder, making dung cakes, picking sag, bundling wheat, picking paddy, and brooming paddy were classified as light activities, with PAR values between 1.0 and 2.5, whereas harvesting wheat, separating paddy, and milking cattle were moderate activities, with PAR values between 2.6 and 3.9 (table 5). The energy cost of different household and farm activities assessed by Caltrac showed that the day of the rural women was crowded with a variety of household tasks, ranging from light to moderately heavy. Spurr et al. [2] also reported light to moderately heavy farm and household activities performed by rural Colombian women.

Conclusions

Although BMR multiples of FAO are used to assess the daily energy expenditure, the energy costs of many activities performed by rural Punjabi women are not available. Caltrac is a simple electronic device that was used to assess the energy costs of some selected household and farm activities. Caltrac underestimated the energy costs of most of the activities, as compared with the physical activity ratio (PAR) calculations using FAO tabulations of the energy cost of specific activities calculated from direct measurements of oxygen consumption. It is concluded that the energy cost values estimated by Caltrac can be used, but they must be calibrated against standard methods.

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Combating iodine deficiency: Lessons from China, Indonesia, and Madagascar

Chor-ching Goh

Key words: Iodine deficiency, economics of health, economic development, human resources, nutrition education, malnutrition, government policy, regulation, food policy, economic behaviors

Editorial note

When iodine was first added to salt in North America and Europe in the middle of the last century, it was in the form of potassium iodide, and the correct terms were iodization and iodized salt. However, this was not practical for the crude, moist salt in most developing countries. The Institute of Nutrition of Central America and Panama first demonstrated, in studies in schools in El Salvador and Guatemala, that the iodine in the water-insoluble potassium iodate was as effective as that in potassium iodide [1], that potassium iodate in burlap bags in the humid tropics was stable [2], and that the addition of potassium iodate to crude salt on a national scale resulted in the disappearance of endemic goiter as a public health problem. Today, potassium iodate is used for almost all salt fortification in developing countries, and the terms iodation and iodated salt have become common. The Bulletin *has adopted these terms as more accurate when referring to salt fortified with potassium iodate and retains the use of iodization and iodized salt where potassium iodide is used, as is still the case in most industrialized countries.*

Editor

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Abstract

This study investigated the factors contributing to a successful and sustainable elimination of iodine-deficiency disorders, drawing from salt fortification experiences in China, Indonesia, and Madagascar. Government officials, salt farmers, salt producers, and wholesalers were interviewed to collect data during field visits. Analyses used in the study include simple correlation, and wherever data permit, regression. The study found that measures crucial for combating iodine deficiency include raising public awareness of the disorders, ensuring easy access to iodated salt, promoting compliance in the salt industry, and monitoring and enforcement. Factors that ensure a reliable supply of iodated salt are equally important as those that create the demand for it. Governments must ensure that surveillance and enforcement mechanisms are functioning right from the time that salt iodation is made compulsory. For sustainability during later years, the adequacy of iodine in iodated salt must be monitored, and incentives must be modified as needed to increase compliance rates in the salt industry. Once national coverage of iodated salt reaches over 90%, the government can concentrate on fine-tuning and targeting resources at areas with a low consumption of iodated salt. Elimination of micronutrient deficiencies has a long-term impact on public health; moreover, poorer segments of the population, who are more vulnerable to such deficiencies, have more to gain from fortification programs. Thus, lessons from the successful elimination of iodine-deficiency disorders are valuable for future similar micronutrient activities.

The author is affiliated with the World Bank in Washington, DC.

A longer version of this paper has appeared in the author's departmental working paper series.

Introduction

Motivation for the study

Prevention of micronutrient deficiencies enhances human development and economic well-being. Although economic development and higher incomes will usually ensure adequate caloric intake, they do not guarantee an adequate intake of micronutrients. This is partly because most micronutrients are present only in selected types of food, but also because people do not have a natural hunger for vitamins and minerals.

The World Development Report 1993 [1] found micronutrient programs to be among the most cost-effective of all health interventions. A comprehensive and sustainable approach to address deficiencies of micronutrients, such as iodine, iron, and vitamin A, would cost less than 0.3% of the gross national product (GNP) a year; in contrast, because of these deficiencies, as much as 5% of the GNP would be lost to deaths, disability, lower educational attainment, and decreased productivity.

Iodine deficiency is well documented as the most easily preventable cause of mental retardation, and its elimination is a recognized priority in the field of nutrition and public health. Although a minute quantity (100 to 150 µg per day) of iodine suffices to ensure a person's iodine adequacy, iodine-deficiency disorders (IDD) remain a major public health problem in many countries. Goiter, stillbirths, miscarriages, neonatal and thyroid deficiency, mental defects, cretinism, spastic weakness, and lesser physical and mental malfunctions are known collectively as IDD.

In 1998 about 740 million people still suffered from IDD [2], a reduction from 911 million in 1990 [3]. The goal of this study was to provide recommendations on how IDD can be effectively controlled. More broadly, the study also draws lessons for future involvement in micronutrient fortification programs and other interventions of a similar nature.

Background

Studies have found that iodine supplementation improves the learning capacity of schoolchildren and reduces the costs of curative medicine [4]. Farm animals share with humans the risk of iodine deficiency at all stages of growth. Iodated salt for animal consumption can improve animal reproduction and the yield of milk and meat, as well as the iodine content of food [5]. A 1994 World Health Organization (WHO)/UNICEF study [6] reported that if consumer salt contains at least 20 ppm of iodine it will ensure that the minimum requirement is met for many domestic animals. There is no apparent risk of toxicity for any class of animals, even if salt contains more than 200 ppm of iodine.

Fortunately, iodine deficiency is one of the simplest micronutrient deficiencies to address. It can be corrected by periodically supplementing the deficient population with iodated oil capsules or other preparations, or by fortifying a commonly eaten food with iodine. In most developing countries, salt iodation has usually been the first large-scale experience in fortifying a food nationwide. If a developing country can effectively institutionalize measures to eliminate iodine deficiency, then addressing deficiencies in vitamin A and iron may be less daunting.

Several foods are possible vehicles to introduce iodine into the daily diet, but salt has become the most commonly accepted. Salt is one of the few commodities that is universally consumed daily, regardless of income, in a small and constant amount; mixing an iodine compound with salt produces no adverse chemical reaction; iodated and noniodated salt are indistinguishable; and the cost of iodation is low, normally in the range of US$0.02–0.07 per kilogram, which is less than 5% of the retail price of salt in most countries. Iodated salt has been cost-effective and successful in eliminating iodine deficiencies for more than 80 years [7]. Unfortunately, in some countries iodation has been an excuse for price-gouging of the poor by charging up to seven times more for salt with iodine [8].

Distribution of iodated oil capsules is still considered a valuable short-term measure. Until iodated salt is widely available, distribution of capsules is appropriate and necessary. Even after iodated salt becomes the primary vehicle to deliver iodine, iodated oil supplements can still play a complementary role. In China, iodated oil capsules are still distributed to pregnant women, newly married couples, children from zero to two years old, and the entire population in areas with at least 2% of cretinism. Similarly, in Madagascar, iodated oil capsules are still being distributed in areas with high IDD prevalence

Overall the provision of incremental iodine through properly iodated salt is safe and has few, if any, side effects [9]. Complications of iodine supplementation can be avoided by adequate and sustained monitoring and control of the level of iodine in salt. Too rapid and massive an increment in iodine intake may carry risks for population groups with severe chronic iodine deficiency. The most serious complication for this group (mainly elderly people with nodular goiters) is the development of iodine-induced hyperthyroidism; the incidence of hyperthyroidism reverts spontaneously to the background rate (or below this rate) after 1 to 10 years of iodine supplementation. Other possible complications include aggravation or induction of autoimmune thyroiditis in susceptible individuals. The prevalence of this adverse reaction is very low and has yet to be clearly demonstrated by large epidemiological, metabolic, or clinical surveys [9].

Approach

Analyses used in the study include simple correlation and, wherever the data permit, regression. Information was gathered by interviews with government officials, salt farmers, salt producers, and wholesalers during field visits to China, Indonesia, and Madagascar. Variables of interest in this study include coverage rates of iodated salt, iodine content in salt, and indicators for iodine status. Common indicators for assessing the iodine status of communities are urinary iodine and the prevalence of goiter among school-age children. Urinary iodine is a marker of dietary iodine intake; the median value in a healthy population is 100 to 200 μg/L. Values between 50 and 99 μg/L suggest mild iodine deficiency, whereas values of 20 to 49 and below 20 μg/L indicate moderate and severe deficiencies, respectively. A goiter is an enlarged thyroid, and its size can be determined clinically by palpation or ultrasonography.*

Analysis

Progress in reduction of iodine-deficiency disorders

The three case-study countries have contrasting industry structures and different scenarios of progress. The Chinese edible salt industry is centrally controlled; the distribution network is monopolistic, and the production has province-specific organizational structures. In Indonesia, over 70% of the salt supply comes from a multitude of small, competing salt farmers. Similar to Indonesia, Madagascar's salt industry is a competitive one, although six large producers supply as much as 80% of its salt for national consumption.

China

Salt iodation began in the 1950s in China, and the sale of iodated salt was concentrated in areas of high IDD prevalence. After 1990, the government required mandatory salt iodation nationwide.

Since 1995, there has been a dramatic reduction in iodine deficiency. The national mean coverage of iodated salt (i.e., the proportion of households consuming iodated salt) reached 93.9% in 1999 (table 1). The quality of salt at the household level has also improved; coverage of *qualified* iodated salt (salt with an iodine content of 20 to 60 ppm) increased from 30% in 1995 to 81% in 1999. The total goiter rate for children nationwide declined from 20.4% in 1995 to 8.8% in 1999. The reduction in total goiter rate during earlier years was a result of both the distribution of iodine oil capsules and increased consumption of iodated salt. Since capsule supplementation was discontinued in 1998, improved iodine status in the population can be assumed to be a result of the use of iodated salt.

In 1999, with the exception of Fujian, Hainan, Qinghai, Xinjiang, and Xizang (Tibet), coverage of iodated salt at the household level reached over 85% in 26 provinces, autonomous regions, and municipalities and over 95% in 18 of them. Iodine-deficiency status, as measured by the proportion of 8- to 10-year-old schoolchildren with enlarged thyroids or low levels of urinary iodine, was found to be highly correlated with the coverage of iodated salt in the vicinity. Evidence in China supports findings elsewhere that as long as iodated salt reaches its population, iodine deficiency disappears. In some areas of western China, the addition of iodine by drip to irrigation water has been effective. IDD still persists in some remote areas of China.

Indonesia

In Indonesia, salt iodation began under Dutch rule in 1927 but ceased in 1945 when the salt monopoly was disbanded. Efforts to combat iodine deficiency began again in 1976, but progress was limited, for three reasons. First, information on the iodine status of the population was not widely available. Second, responsibility and accountability for enforcement were unclear

TABLE 1. Main indicators of iodine status in China in 1995, 1997, and 1999

Indicator	1995	1997	1999
Iodated salt			
National mean coverage (%)	80.2	90.2	93.9
% of qualified iodated salt samples			
Iodine level ≥ 20 ppm	39.9	81.1	88.9
Iodine level 20–60 ppm	29.7	69.0	80.6
Urinary iodine content among schoolchildren aged 8–10yr[a]			
Median household iodine level (ppm)	16.2	37.0	42.3
Average (μg/L)	164.8	330.2	306.0
% with iodine content < 50 μg/L	13.3	3.5	3.3
No. of provinces with median iodine < 100 μg/L	5	1	1
Total goiter rates among schoolchildren aged 8–10 yr (%)			
Tested by palpation	20.4	10.9	8.8
Tested with B-ultrasound	—	9.6	8.0
Grade 2 goiter	2.1	0.5	0.3

Source: Findings from National IDD Surveys of 1995, 1997, and 1999, analyzed and prepared by the Chinese Research Center for Diseases Control (Ministry of Health), in table 27 of The Discussion Draft: 1999 Monitoring Report on China Iodine Deficiency Disorders, presented in the Fuzhou Iodine Deficiency Disorders Conference (December 17–18 1999).

a. The median value of urinary iodine in healthy populations is 100 to 200 μg/L.

Table 2. Coverage of iodated salt in Indonesia for 1995 to 1999

Indicator	1995	1996	1997	1998	1999
% of households consuming iodated salt (> 5 ppm)	78.2	83.5	85.1	80.3	81.5
% of households consuming qualified iodated salt (30–80 ppm)	49.8	58.1	62.1	65.2	63.6

Source: Information on iodated salt comes from the National Household Surveys (SUSENAS) of 1995–1999, analyzed and prepared by the Statistics Bureau in Konsumsi Garam Beryodium di Rumah Tangga, 1998 and 1999 [17].

within the government. Third, there was no mechanism for coordination among the various ministries involved and the private sector.

The Indonesian Government re-embarked on a nationwide IDD control program in the mid-1990s. However, progress has been slower than expected, because underlying problems of poor accountability and weak enforcement remain. In addition, the regional financial crisis has brought about economic and political turmoil in Indonesia that still affects a large part of the country today.

The national coverage of iodated salt (> 5 ppm) at the household level increased from 78.2% in 1995 to 81.5% in 1999, while the coverage of *qualified* iodated salt (30–80 ppm) rose more substantively, from 49.8% in 1996 to 63.6% in 1999 (table 2). Total goiter rates fell from 37.2% in 1980–1982 to 9.8% in 1996–1998 (table 3), but it is important to note that the three rounds of surveys on goiter prevalence are not perfectly compatible, and the information is at best a rough comparison. During 1996–1998, 8.4% of Indonesian subdistricts (with 8.8 million inhabitants) were still classified as having severe levels of endemic goiter (table 4). A test on schoolchildren in 1999 found that 23% percent of them had urinary iodine levels less than 100 µg/L. About 33% had levels of 100 to 200 µg/L, and 44% had levels over 200 µg/L. Information on urinary iodine of children is taken from the ThyroMobil Surveys of 29 countries, which included Indonesia. Part of the summary findings from the ThyroMobil Surveys were reported in the ICCIDD Report 1999, presented by the International Council for Control of Iodine Deficiency Disorders in the 27th Session of the Sub-committee on Nutrition in Washington, DC, April 10–14, 2000.

It is unclear whether reduced goiter prevalence is primarily a result of supplementation with iodated oil capsules or improved coverage of qualified iodated salt [9]. The most recent survey indicates that oil capsule coverage of pregnant women was less than 20% in 76% of districts, and only 3% of districts had coverage of over half of the pregnant population [10].

TABLE 3. Indicators of iodine status in Indonesia

Indicator	1980–82	1990	1996–98
Total goiter rates (by palpation) among schoolchildren aged 6–12 yr (%)	37.2	27.7	9.8
Urinary iodine content among pregnant women[a]			
Average of median levels for provinces (µg/L)[b]			161.32
Provinces whose first quartile of urinary iodine content was < 50 µg/L (%)			21
Provinces whose first quartile of urinary iodine content was < 100 µg/L (%)			33
Provinces whose median urinary iodine content was < 100 µg/L (%)			21

Source: ref. 10.

a. The median value of urinary iodine in a healthy population is 100 to 200 µg/L. Only the survey of 1996–1998 is nationally representative. The sampling framework for the surveys in 1980–1982 and 1990 might produce an upward bias in the national estimates. All three surveys are not perfectly compatible, and the information provided is at best a rough comparison.

b. National median or average levels of urinary iodine levels were not calculated. The average of the median for the provinces was calculated by averaging all provinces' median levels of urinary iodine. This estimate, albeit crude, attempts to provide an overall picture of the situation.

Madagascar

Unlike China and Indonesia, salt iodation in Madagascar only began in the early 1990s. IDD was prevalent among the population in the highlands; their condi-

TABLE 4. Proportion of subdistricts categorized by degree of severity based on total goiter rates (by palpation) among 1.2 million schoolchildren aged 7–12 yr in Indonesia (1996–1998)[a]

Degree of severity (total goiter rate)	No. of subdistricts	Proportion (%)
Severe (> 30%)	334	8.4
Moderate (20%–30%)	278	7.0
Mild (5%–19%)	1,167	29.9
Nonendemic (< 5 %)	2,184	54.7
Total of all subdistricts	3,963	100.0

Source: ref. 10.

tion is exacerbated by a high level of consumption of goitrogenous cassava, particularly among the poorest communities. Since 1992, sentinel sites have been established to monitor IDD among children and household salt consumption. The sentinel sites are in Betroka (Toliary), Belazao and Ambohidratrimo (Antananarivo), Fandriana (Fianarantsoa), Ranomafana-Est (Toamasina), Bealanana (Mahajanga), and Maroabihy-Est (Antsiranana). The sentinel sites are in charge of collecting salt samples and urine samples from primary schoolchildren and sending them to be tested in the capital once a year. Four of the six provinces (Toliary, Antananarivo, Toamasina, and Finanrantsoa) also have laboratories to test salt samples from production sites and the marketplace.

Table 5 shows various indicators, collected at sentinel sites, of national progress in controlling IDD between 1992 and 1999 [11–13]. Coverage of iodated salt (> 5 ppm) at the household level increased from zero in 1992 to 98.3% in 1999. Levels of urinary iodine in children have also risen: the proportion of children with less than 50 µg/L of urinary iodine has fallen from 70.7% to zero. Total goiter rates among primary schoolchildren declined from 45.1% to 7.1% during this period [11–16].

Achieving and sustaining salt iodation

Although salt iodation is technically a straightforward process, its large-scale implementation often involves political, administrative, technical, and sociocultural changes. IDD awareness that creates demand for iodated salt and enforcement and compliance in the entire salt sector are essential factors for successful and sustainable salt iodation. Once iodation of salt is established as a permanent measure, it prevents recurrence and virtually eliminates iodine deficiency.

Awareness of IDD

In many countries, communities perceive goiter as normal, and the lack of awareness also exists among health workers and decision makers. Uninformed consumers who resist change will be an obstacle to eliminating IDD, whereas informed consumers who demand iodated salt will become a self-sustaining force.

High-level political commitment in China initiated the iodation program and sustained its momentum. Health officials and the salt industry have also intensively promoted public awareness of IDD through many channels, ranging from advertisements on public buses to editorials in newspapers. In Madagascar, besides using standard informational campaigns, the Ministries of Commerce and Health publicize their “check-and-seize” operations, which confiscate noniodated salt. Similarly, government commitment and the use of radio, television, traditional drama, teachers, and village health volunteers were effective in Ecuador and Bolivia [7].

In China, awareness of IDD among provincial governors has brought about prompt action. For example, when Guangxi changed its governor, commitment to IDD control in remote villages lapsed. Direct sale of iodated salt to remote villages stopped, and indicators of iodine deficiency deteriorated. However, after the new governor was informed, efforts resumed and the situation was reversed. Smuggling of noniodated

TABLE 5. Indicators of national progress in IDD control in Madagascar, 1992–99[a]

Indicator	1992	1995	1996	1997	1998	1999
Coverage of iodated salt at household level (%)	0.0	0.0	83.1	92.0	96.6	98.3
Level of urinary iodine in schoolchildren 6–12 yr old						
Average (µg/L)	41.5	74.1	170.3	160.0	—[b]	—[b]
Median (µg/L)	—	70.2	161.2	148.3	156.8	—[c]
< 20 µg/L (%)	16.0	5.0	0.9	0.7	0.0	—[c]
< 50 µg/L (%)	70.7	25.8	3.8	0.7	0.0	—[c]
>100 µg/L (%)	0.0	23.8	78.8	85.7	91.2	—[c]
Total goiter rates (by palpation) of schoolchildren 6–12 yr old (%)	45.1	22.4	16.0	15.1	8.7	7.1

Source: refs. 11–13.

a. Nationwide salt iodation began in 1995, and iodated salt reached the market by December 1995. The median value of urinary iodine in a healthy population is 100–200 µg/L.

b. Averages have not been calculated since 1998. Instead, only the medians are reported to better reflect the distribution.

c. Data on urinary iodine content for 1999 were sent to the Division of Nutrition Services in Antananarivo early in 2000, and analyses were not yet available as of April 2000.

salt was rampant in bordering counties in Shandong, Henan, and Hebei Provinces. These areas are designated economic development zones, and local governments tend to adopt a laissez-faire attitude. However, publicity implemented by salt officials through television and newspapers has motivated local governments to act.

In contrast, mobilization of local governments to support IDD control in Indonesia has been limited, and the interest of leaders is generally lukewarm. Accountability and responsibility for enforcement are unclear among central ministries, provincial governments, and local governments. One approach to address recalcitrant and unabated incidence of IDD is to seek commitment directly from district heads (Bupatis). Another is to involve communal nongovernmental organizations (e.g., Persatuan Kesejahteraan Keluarga and Nahdlatul Ulama), mosques, and schools in monitoring salt, using low-cost field test kits to increase awareness and community participation.

Access to iodated salt

Despite its importance, public awareness will be futile if adequately iodated salt is not easily available to the population. Some 40% of rural households in Indonesia have cited nonavailability of iodated salt in grocery shops as their reasons for consuming noniodated salt, while only 14% cited price as a factor [17]. In Indonesia, the correlation between IDD knowledge and willingness to purchase iodated salt, as shown in figure 1, is significantly positive at 0.87 (standard error of 0.09). However, the public is not necessarily more aware of IDD in provinces with high coverage of iodated salt. In provinces with coverage of over 80%, the proportion of the people who know about IDD ranges from 49% to 81% (fig. 2). There are similar findings where there was no correlation between the population's knowledge of IDD and coverage of qualified (30–60 ppm) iodated salt in provinces with more than 85% of coverage [18].

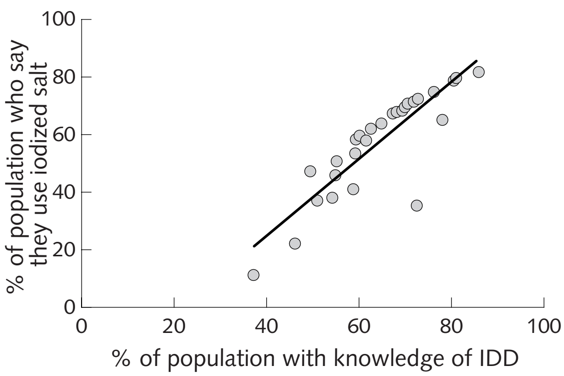

FIG 1. Relationship between knowledge of IDD and willingness to purchase iodated salt in Indonesia (1999) Source: ref. 17

Similarly, there is no statistically significant correlation between public awareness of IDD and iodated salt coverage in China (fig. 3). The average scores on knowledge of IDD range between 72 and 92 for provinces with high coverage (over 85%); they also range between 71 and 94 for provinces with low coverage (less than 85%). Such findings indicate that knowledge of IDD that creates demand for iodated salt is a necessary but not sufficient condition to ensure consumption of iodated salt. A reliable supply of iodated salt for the population is equally critical. The importance of access to and availability of iodated salt is illustrated by the example of Lhasa, where in 1998 the Chinese Government established a salt factory to address the difficulty of delivery from coastal producers to inland Xizang. According to Ministry of Health officials, analysis

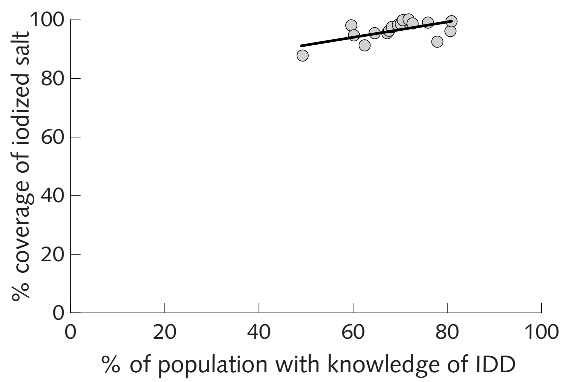

Fig 2. Relationship between knowledge of IDD and coverage of iodated salt (> 80%) in Indonesia (1999). Correlation oefficient = 0.15 (standard error = 0.14). Source: ref. 17

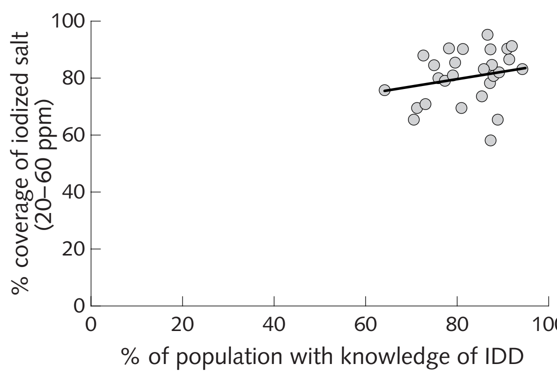

FIG. 3. Correlation between knowledge of IDD and coverage of iodated salt in China (1999). Correlation coefficient = 0.31 (standard error = 0.22) . All provinces, autonomous regions, and municipalities are included except outlying Tibet (coverage, 28%; score, 54), Hainan (coverage, 38%; score, 65), and Qinghai (coverage, 55%; score, 45). Source: Data are taken from the 1999 Monitoring Report of China IDD, prepared by the Preventive Disease Research Center of the Ministry of Health, for the Fuzhou Conference held in December 1999

of the 1999 National Household Survey suggested that iodine status in the greater Lhasa area has since improved significantly.

Compliance with iodation

To ensure effective iodation and distribution of iodated salt, given the limited public resources and capacity in developing countries, governments must align incentives vis-à-vis the self-interests of parties involved (the salt industry and the consumers) at the appropriate levels (production, distribution, and retail) so that they will willingly police one another. In many cases, persuasion and direct assistance from governments may also be necessary to motivate the industry to cooperate and comply with iodation.

In China, besides its effective formal enforcement, the monopolistic structure of the salt industry is creating additional incentives for wholesale distributors to police and uproot unauthorized salt. In provinces such as Fujian, Guangdong, and Liaoning, where many local residents produce sea salt of variable quality, the China National Salt Industry Corporation stepped in to facilitate the sale of raw salt to larger salt plants and to refinement centers for iodation. Such support to small licensed producers is an attempt to reduce the amount of noniodated salt in the market. Ecuador emphasizes a good relationship with producers by instituting annual information and motivational meetings. Bolivia stresses cooperation from small salt manufacturers, and Cameroon achieves compliance from the country's sole refiner. These are the major reasons for their success with iodation [7].

In Madagascar, authorities may need to consider shifting their focus from noncomplying small salt producers to distributors. Small salt producers are numerous, elusive, and uncontrollable, whereas distributors are few and more manageable. Since all salt producers sell through the wholesale channel, authorities can provide disincentives (confiscation or fines) to discourage wholesale distributors from purchasing noniodated salt. Distributors' demand for iodated salt may be more effective in motivating salt producers to iodate.

In Indonesia, noniodated salt comes from two sources. First, salt farmers sell raw, noniodated salt to grocers or consumers. Some 25,000 salt farmers supply 80% of the total raw salt (90,000 tons/year) to about 300 salt-processing plants to process and iodate, while state-owned PT Garam produces and processes the other 20%. Second, many salt-processing plants do not iodate as required. National Indonesian Standard (SNI) licenses are given to producers that have fulfilled certain criteria regarding salt quality and internal quality control. Only 40% of its 182 salt-processing plants had obtained the SNI licenses by May 2000. In 2000, the Ministry of Industry and Trade had just begun to work together with salt producers to help them secure SNI licenses. Enforcement at the retail level is crucial, since 30% of the population buy salt from a market vendor and 60% buy it from grocery shops. The remaining 10% of the population purchase salt from other sources (e.g., salt from door-to-door salesmen or raw salt in the area). There is no significant difference between urban and rural inhabitants [17]. Some disincentives may be imposed on grocery stores to deter them from selling noniodated salt. Similarly, salt farmers must be discouraged from peddling their raw, noniodated salt in the market.

In addition to penalties, assistance may be necessary. First, the Ministry of Industry in Indonesia may need to extend assistance (technically and financially) to processing plants to facilitate their compliance with iodation. Second, problems of liquidity constraint faced by salt farmers must be addressed. Raw salt is sold to processing plants, usually on credit, through intermediaries. Hence, salt farmers who are cash-constrained with a tight profit margin prefer to peddle their raw salt, albeit illegally, in the market. If authorities can intervene to improve farmers' terms of trade with salt-processing plants that are certified (with the National Indonesian Standard), through moral suasion or subsidies of iodate for processing plants, salt farmers may have greater incentives to sell to them.

Grouping Indonesian salt farmers into cooperatives may help strengthen their bargaining position; moreover, micro-credit can be extended through the cooperative to ease the salt farmers' liquidity constraints before the salt harvest. Conditions for micro-credit can be stipulated so that salt serves as collateral and members have incentives to monitor one another on repayment. However, a careful study must be undertaken before proceeding with a micro-credit program, since potential benefits can be nullified by weak enforcement.

Enforcement

Besides aligning incentives to promote compliance, governments need to monitor the industry closely. Many countries have legislation on mandatory salt iodation, but enforcement is more critical. Given that consumers cannot easily distinguish between noniodated and iodated salt, the government must strictly enforce that salt sold to the population is appropriately iodated. Frequent testing of iodine content at production sites and periodically at intermediate points in the distribution network, retail outlets, and households, as well as effective enforcement, has been characteristic of successful programs. Ecuador and Brazil sampled salt on a weekly basis at production plants during early phases of the fortification program. Bhutan has developed a systematic monitoring and reporting system for iodine content at production, distribution, and consumption sites, where reports are reviewed centrally every month. In Ecuador, legal sanctions in the form of fines and newspaper publication of noncompliant brand names are also used [7].

In China, the industry has its comprehensive internal surveillance system at all manufacturing stages, and health officials make regular visits to producers, distributors, retailers, and households to examine salt samples. The provincial governments of Hunan and Tianjin reimburse their health bureaus for carrying out tests on salt samples. In other provinces, the testing of salt samples is either financed solely by the salt industry or shared between industry and the health sector.

In Indonesia, there are monitoring activities at the production, market, and household levels, but no follow-up corrective actions have been taken. A comprehensive IDD mapping for all Indonesia has been implemented, but it is extremely costly, and the benefits may not be large enough to justify such an exercise. Instead, in a more cost-effective exercise, the Department of Statistics, with the project's funding, has included several questions on iodated salt in its yearly household surveys (SUSENAS). Such a supplementary survey is very helpful in providing information on coverage and consumption rates of iodated salt, effectiveness of informational campaigns, demand factors, and regional lapses in supply. Sampling of urine among primary schoolchildren can be undertaken during the survey. It is unclear whether the Department of Statistics will continue with the survey on consumption of iodated salt in the SUSENAS.

A large amount of data has been collected since 1996, but because of inconsistent sampling frameworks, very little analysis has been done. Available data in the island provinces of Java and Bali indicate that coverage of iodated salt did not improve much between 1997 and 1998 (fig. 4). Except for a few *kabupatens (*districts*)*,

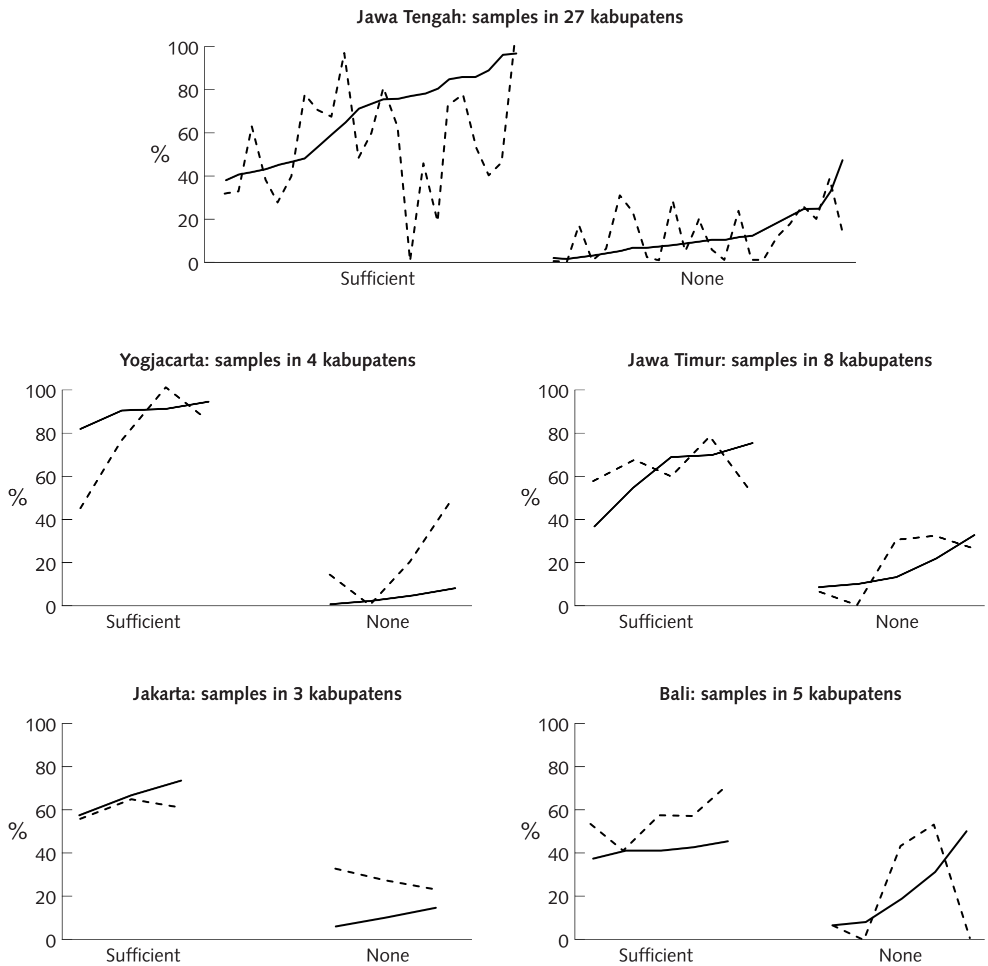

FIG. 4. Percentages of salt samples with sufficient amount of iodine and without any iodine for various regions of Indonesia in January–March 1997 and January–March 1998. Data for 1997 are for salt samples taken at the household level; data for 1998 are for samples taken at the retail market level

the proportion of salt samples with adequate iodine has fallen and the proportion with no iodine has risen. Table 6 shows that in all but one *kabupaten* of East Java (with consistent data), the proportions of noniodated salt sold at the market level have actually risen between 1998 and 2000 [19].

Monitoring systems must also include rapid analysis and dissemination of data to inform the authorities of necessary corrective actions. In China, data collection and analysis of monitoring activities and progress are undertaken at the Technical Center of International Cooperation Program on IDD (Ministry of Health). In Madagascar, the Division of Nutrition Services (Ministry of Health) has the sole responsibility for overseeing iodine laboratories and monitoring iodine status. In contrast, dissemination of information is slow in Indonesia. Several agencies are charged with monitoring at various levels, and information is sent to different agencies to be processed. Inconsistency and incompatibility among data further complicate analysis and dissemination.

TABLE 6. Percentage of noniodated salt sold in the markets of five kabupatens (districts) in East Java, Indonesia, between 1998 and 2000

Kabupaten	1998	1999	2000
Magetan	7.6	11.5	20.1
Mokokerto	5.5	2.2	0.6
Madiun	10.6	11.6	6.3
Kediri	3.5	4.9	5.0
Pacitan	0.9	2.2	7.0

Source: ref. 19.

Quality control

Quality control is important in salt iodation. Monitoring iodine content not only ensures adequacy of iodine intake but also prevents hyperthyroidism, which can be triggered by excessive iodine intake after prolonged deficiency. The following analysis highlights the importance of quality control in reducing IDD.

Regressions on China's 31 provinces, autonomous regions, and municipalities in 1995, 1997, and 1999 analyzed the impact of iodated salt coverage and salt quality on total goiter rates. Robust standard errors were calculated in the regressions to reflect correlated cluster effects of states between years. Total goiter rates include grades 1 and 2 goiter. The median value of iodine content (ppm) in the samples measures salt quality. Two indicators of iodated salt coverage are used: the percentage of salt within the range of 20 to 60 ppm, and the percentage of salt with at least 5 ppm iodine. The latter indicator is used in most countries to quantify coverage. Table 7 shows that when the quality proxy (iodine content in salt) is included in the regression, the effect of coverage of iodated salt on

TABLE 7. Impact of iodated salt coverage and quality of salt on total goiter rates in Chinese provinces, 1995–1999[a]

Independent variables	Regression used: Total goiter rate$_{it} = \alpha_0 + \alpha_1$ (coverage of iodated salt)$_{it} + \varepsilon_{it}$	Regression used: Total goiter rate$_{it} = \alpha_0 + \alpha_1$ (coverage of iodated salt)$_{it} + \alpha_2$ (quality of iodated salt)$_{it} + \varepsilon_{it}$
Coverage (%) of iodated salt with 20–60 ppm iodate	–0.199 [0.038]	–0.098 [0.048]
Quality of salt samples measured by the median ppm of iodate	—	–0.251 [0.106]
Total no. of observations	82	82
Total no. of provinces	31	31
R^2	0.2408	0.2856
Coverage (%) of iodated salt with ≥ 5 ppm iodate	–0.178 [0.069]	–0.110 [0.069]
Quality of salt samples measured by the median ppm of iodate	—	–0.194 [0.119]
Total no. of observations	60	60
Total no. of provinces	31	31
R^2	0.2000	0.2357

Source: The data come from a report, 1999 Monitoring Report of China IDD, prepared by the Preventive Disease Research Center of the Ministry of Health for the Fuzhou Conference held in December 1999.

a. Robust standard errors are below the reported coefficients estimates in square brackets. The quality of iodated salt is defined as the median ppm of iodate in salt samples for that province. The coverage of iodated salt with ≥ 5 ppm iodine was not reported in 1995, and therefore, in the lower panel of the regressions, only 1997 and 1999 are used.

total goiter rates falls sharply. Thus, iodine content, and not merely the presence of iodine, in salt determines the reduction in IDD.

Weak quality control for iodation programs in Madagascar risks reversing the progress made thus far. Control of iodine content in salt has been poor. The coverage of iodated salt is almost universal, but the iodine content of the salt varies widely. Table 8 shows that barely half of the salt samples fall within the qualified interval of 30 to 60 ppm iodine. For example, in Antananarivo, the minimal iodine content in its samples is only 7.4 ppm, whereas the maximum reaches 209 ppm. La Companie Salinière de Madagascar, the only plant with internal quality-control units in Madagascar, has supplied its home province of Antsiranana with salt of more consistent quality. Its salt samples were well within the interval of 27 to 48 ppm of iodine. Another effective means of monitoring iodine sufficiency, neonatal screening, was not used.

Intervention in problematic areas

Non-salt-producing remote areas

When national coverage of iodated salt reaches over 90%, monitoring mechanisms and enforcement can be considered to be effective. The remaining problems often lie in pockets of poverty in remote areas, where access is difficult and the population is uninformed. By direct-sale methods, iodated salt can still reach the population, as long as raw salt is not readily available. In China, several provinces have implemented direct sale of iodated salt in villages. Guangxi, Hebei, and Shandong Provinces have been effective in persuading the inhabitants of mountainous areas to purchase iodated salt that is delivered directly to their villages. However, in other provinces, where local authorities were not committed, wholesalers were unable to collect payment for their shipments, and delivery ceased. Similarly, access to iodated salt is difficult in many remote villages in Indonesia. Intervention by subdistrict heads in the direct sale of iodated salt through local nongovernmental organizations such as the Women's Welfare Organization (Persatuan Kesejahteraan Keluarga) or the Organization of Religious Leaders (Nahdlatul Ulama) will be necessary.

Salt-producing regions

In regions where raw salt is readily available, the direct-sale approach often breaks down. In China, inhabitants with easy access to salt hills, dehydrated salt lakes (e.g., Xinjiang), or sea salt (e.g., Jiangsu) refuse to pay for salt. However, officials have found that inhabitants of salt mountains of Xinjiang purchase refined salt in the market, but it is considered a superior product that is used solely to pickle vegetables and meat. In Indonesia, the use of noniodated salt at the household level is rampant in salt-producing provinces, ranging from 23% in East Java to 48% in South Sulawesi in 1999 [11]. At the market level, half of the salt sold in salt-producing provinces bears no trademark or company name on the packaging [20]. In such cases, enforcement must be strengthened.

To tackle the remaining problems in areas where the population is unreceptive to the benefits of iodated salt, authorities must identify the reasons for not consuming iodated salt and formulate alternative remedies accordingly. Is it just habit and tradition? Is the price of iodated salt a deterrent when raw salt is easily available? Is it poor awareness of IDD? In some cases, increasing public awareness may be sufficient to address the problems; however, in others, iodating well water or water

TABLE 8. Quality indicators of iodated salt in 1998 for various provinces in Madagascar: proportion of salt samples with 30 to 60 ppm iodine and the range of iodine content in salt samples

Indicator	Antananarivo	Toliary	Fianarantsoa	Toamasina	Antsiranana	Mahajanga[a]
Proportion of salt samples[b] testing positive for iodine by field test kits (%)	94.8	85.2	93.5	96.5	98.6	99.7
Proportion of salt samples[c] with 30–60 ppm iodine, by titration at laboratory (%)	58.9	33.3	55.9	35.0	80.0	—
Salt samples with:						
Minimal iodine level (ppm)	7.4	1.9	11.1	18.7	27.4	20.63
Maximal iodine level (ppm)	209.9	35.4	55.5	66.5	48.1	69.83
Mean iodine level (ppm)	46.9	21.3	30.3	29.5	35.8	26.54

Source: ref. 12.

a. Although there are no data for the entire province of Mahajanga, information in this column is obtained from salt samples from the market in Bealanana in Mahajanga.

b. Salt samples are collected monthly from school children in sentinel sites by the District Nutrition Services Division.

c. Salt samples are collected by officials at the Ministry of Health laboratories several times a year. Laboratories in the provinces of Antsiranana and Mahajanga were established recently (1999), and there have been no data yet from the laboratory of Mahajanga.

for irrigation may be a more effective means to deliver iodine to the population. Alternatively, distribution of oil capsules or injection of time-release iodine oil every few years to a nomadic population in remote areas may be the solution.

Discussion

Although this study focused narrowly on salt iodation, recommendations from experience with IDD may be more broadly applicable to other food-fortification programs. When food fortification is chosen as the strategy to address micronutrient deficiencies, issues related to encouraging acceptance of fortified food, on the demand side, and motivating the industry involved, on the supply side, are similar to those for salt iodation. Because consumers cannot easily differentiate between fortified and nonfortified goods, commodities with few producers should preferably be considered as vehicles to deliver micronutrients. This will greatly facilitate the government's role in monitoring and enforcement.

Findings

The case studies reaffirm outcomes elsewhere that consumption of iodated salt eliminates iodine-deficiency disorders and prevents recurrence. In turn, the population will only consume iodated salt if there is a reliable supply of it. In countries where endemic goiter is a public health problem, ideally all salt for human consumption should contain iodine. Because informed consumers cannot readily differentiate between iodated and noniodated salt, intervention by the government as a monitor and enforcer is necessary. Enforcement is also important, because the quality of iodation matters. Excessive intake of iodine may trigger hyperthyroidism in those with chronic iodine deficiency, whereas inadequately iodated salt is inefficient in ameliorating the iodine status of the population.

Recommendations

The lessons from salt-fortification activities can be generalized to all other food-fortification programs that address micronutrient deficiencies. The government must ensure that surveillance and enforcement mechanisms are functioning at the onset. Monitoring systems must also include rapid analysis and dissemination of data to inform authorities of corrective actions. In this light, responsibilities pertaining to control of micronutrient deficiencies (e.g., laboratories, data collection and analysis, and monitoring) can be consolidated under one division of a ministry (e.g., Health) to maximize the effectiveness of monitoring efforts and minimize bureaucratic friction among ministries.

During the later years of food-fortification programs, the authorities can concentrate on quality-ameliorating measures, such as improving fortifying techniques to prevent large variance in the concentration of the micronutrient. Meanwhile, incentives may need to be modified to increase the compliance rate in the industry. Incentives (or disincentives) must be tailored according to industry structures and distribution networks to bring about total compliance with fortification. Incentives directed at the demand and profit interests of the industry can be adjusted to ensure a reasonable level of self-policing. In addition, persuasion and direct assistance may be necessary to motivate the industry to cooperate and comply.

Interventions may be necessary in areas with continued deficiencies. Direct subsidized sale of fortified food through village heads or local nongovernmental organizations may be used; other strategies utilizing different vehicles to deliver the micronutrient and supplementation through use of capsules or injection may also be considered as intermediate-term and longer-term measures.

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Iodine fortification is related to increased weight-for-age and birthweight in children in Asia

J. B. Mason, M. Deitchler, A. Gilman, K. Gillenwater, M. Shuaib, D. Hotchkiss, K. Mason, N. Mock, and K. Sethuraman

Key words: iodine, iodated salt, birthweight, anthropometry, child growth, Asia

Editorial comment

The following is a review of recent information on the effect of iodine supplementation on weight-for-age based on data from Bangladesh, India, Sri Lanka, Nepal, and the Philippines. Although there is extensive pediatric literature that emphasizes that the first clinical evidence in permanent sporadic congenital hypothyroidism is the slowing of growth, this has not been extrapolated to populations with endemic goiter. Thus, a conclusion that is obvious to most pediatricians is not recognized by public health workers.

There are weaknesses to the present analysis that the authors point out in the Discussion. Among them, the data are mostly cross-sectional, which allows only the comparison of current anthropometry with current iodine access. Because body size is the result of earlier changes, the assumption had to be made that households with iodated salt at the time of survey were more likely to have had iodated salt at an earlier time, and vice versa. Departures from this add to the error and thus weaken the effect observed, but they should not be biased by it.

There is also a likelihood that households with iodated salt are more accessible and have better socioeconomic and environmental conditions that would favor better anthropometric indices in children. This potential confounding factor was extensively investigated. A number of factors measured were associated with both anthropometry and iodated salt. The relationships of anthropometry with iodine persisted when these potentially confounding factors were controlled by regression or stratification. However, the association with iodine is among the strongest seen with any variable.

Because of the nature of the datasets, the sole indicator of iodine status was the iodine content of the salt consumed, as measured by kits. Such measurements are qualitatively reliable but quantitatively imprecise. Unfortunately, it was not possible to provide any direct evaluation of the status of iodine nutrition or thyroid function. Therefore, it cannot be assumed that these findings apply to individuals, but they can be reasonably assumed to apply to populations, the goal of public health research.

For those wishing to explore further the relationship between iodine deficiency and growth and development, there are several monographs that should also be consulted [1–4].

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J. B. Mason, D. Hotchkiss, and N. Mock are affiliated with the Department of International Health and Development, Tulane University School of Public Health and Tropical Medicine, in New Orleans, Louisiana, USA. M. Deitchler is affiliated with the Food and Nutrition Technical Assistance Project, Academy for Educational Development, in Washington, DC. A. Gilman is affiliated with the UNICEF country office in Kathmandu, Nepal. K. Gillenwater is affiliated with the Medical School, University of Texas, in Galveston, Texas, USA. M. Shuaib is affiliated with the Institute of Statistical Research and Training, Dhaka University, in Dhaka, Bangladesh. K. Mason is affiliated with the Department of Public Health, Louisiana State University Health Sciences Center, in New Orleans. K. Sethuraman is affiliated with the Institute of Child Health in London.

Abstract

Severe iodine deficiency causes stunting and mental retardation in utero, but the relation between mild deficiency and child growth is not well known. The use of iodated salt in relation to anthropometric data was examined from recent survey data. After potential confounding factors had been controlled for, significant associations were seen in Bangladesh, India, Nepal, and Sri Lanka. The use of iodated salt was related to increased weight-for-age and mid-upper-arm circumference, most strongly in the second year of life, mainly affecting soft tissue (thinness). The relation with weight-for-age was greater among children of mothers with lower body mass index. The use of iodated salt was related to birthweight in Sri Lanka and in the Philippines, where iodated oil capsules given during pregnancy had a negative effect when used with high levels of iodine in salt. The associations generally were concentrated in large geographic areas, possibly because of interactions with other environmental factors (e.g., selenium and arsenic). The apparent growth response to iodine may reflect functional effects of mild deficiency, which is widespread, possibly including effects on brain development.

Introduction

Severe iodine deficiency causes an array of defects, including mental retardation and stunted physical growth (cretinism and dwarfism) [1–3]. Goiter, as the most commonly assessed sign of iodine-deficiency disorder (IDD), is estimated to affect over 500 million people worldwide [4, 5].

The extensive benefits of preventing severe iodine deficiency, especially by eliminating developmental defects in children, have been shown in several classic studies [6–9]. Improvement of intellectual ability by reversing the effects of current iodine deficits has been demonstrated in Ecuador, Bolivia, and Malawi [10–12]. Severe deficiency (e.g., manifested as cretinism) is receding [4], but mild deficiency remains widespread, with potentially far-reaching consequences for human development.

The effects of subclinical IDD are less well known than those of the severe syndrome. Intellectual abilities are known to be affected, probably in at least two ways: by developmental damage *in utero*, which is largely irreversible; and by iodine deficiency in early childhood and later life, with lower thyroxin levels leading to reduced intellectual and physical vigor, which can be improved by iodine supplementation [12–14].

Few population studies have examined the relationship of mild IDD to child growth. Those identified in a literature search showed varying results, from both observational and intervention investigations. Thyroid size was not observed to be associated with growth in Bolivia and Malaysia [10, 15]. However, maturation (as measured by bone age) was retarded, along with height, in school-age children in IDD endemic areas in Iran [16] and India [17]. In the Iranian study, this retardation was linked to elevated levels of thyroid stimulating hormone (TSH). In an earlier study in Greece [18], children in areas of endemic goiter were smaller than those in nonendemic areas, but this difference was not related to thyroid size. In intervention studies, thyroxin administration increased growth in hypothyroid Colombian children with minimal thyroid dysfunction [19]. Household use of iodated salt was associated with height in preschool children in Kenya, the effect remaining significant when socioeconomic factors as well as parental size were controlled for [20]. Allen [21] pointed to a likely association of marginal deficiency with growth, noting that birthweight was reported to be increased with supplementation of iodated oil to women. Children born to mothers treated with lipiodol (0.5 ml) had a mean birthweight 200 g higher than those born to mothers not treated with lipiodol [22]. In Bangladesh, provision of iodated oil in pregnancy led to an increase in birthweight of about 110 g [23]. In Indonesia, an effect of iodine supplementation was found on child mortality [24] but not on child growth (C. Cobra, World Bank, 1996). It has been concluded that “while clinical hypothyroidism is a well recognized cause of short stature in children, little is known about minimal thyroid dysfunction on growth” [19].

The mechanism whereby mild IDD could retard growth and iodine repletion could produce a growth response is reasonably clear in general terms. Thyroxin affects growth through growth hormone and through insulin-like growth factors [25–27]. Part of this effect is on epiphyseal growth itself, directly influencing height and (presumably) bone age. The possible relative effects on growth *in utero* and postnatally are less clear.

Maternal thyroid function and an adequate supply of iodine to the fetus are required during pregnancy for fetal growth and development [28], and this probably applies when deficiency is mild, so that virtually no cretinism is seen, as is the case today in most affected countries [4, 5]. The recent intervention trials of iodine supplementation during pregnancy in Bangladesh [23] and Algeria [22] were not conducted in conditions where severe deficiency was the norm, but they still showed a significant increase in birthweight. There are some concerns about giving supplementary iodine (as iodated oil) in pregnancy because of the possibility of inducing an inhibition of fetal and neonatal thyroid hormone synthesis with excess iodine, although the World Health Organization (WHO) concluded that the risk was slight and that the benefits should outweigh the risks [29]. This concern relates to the observation that congenital hyperthyroidism can cause growth restriction [28]. Thus, the relation of growth to thyroid function may be U-shaped, with both abnormally low and abnormally high levels causing growth restriction. However, coupled with the likely benefit of supplementation on intrauterine development in most circumstances, these concerns would make further intervention trials problematic, so that observational studies are more feasible.

A general growth response to iodation in IDD-affected areas is a reasonable expectation, but one that has not been widely observed. The massive effort presently under way to achieve universal salt iodation—74 of 99 developing countries studied are now iodating salt [5]—provides for a unique natural experiment. Birthweight and child growth may be markers for the effects of iodine deficiency, responding to increased iodine intake and also implying likely involvement of intellectual development. The opportunity first arose to investigate this issue in Bangladesh, where secondary analysis of a large-scale general-purpose health and nutrition survey was undertaken for purposes of project planning [30]. Data allowing for similar analysis later became available for Sri Lanka, Nepal, India, and the Philippines. Subsequently, data from the 1999 annual UNICEF-sponsored Bangladesh survey became available. This paper presents the results obtained from multivariate analysis of the six datasets, specifically reporting the relationship between access to iodine and infant and child growth in iodine-deficient areas in Asia.

Data and methods

The data for the analyses reported here were obtained from three sources: Multiple Indicator Cluster Surveys (MICS), supported by UNICEF [31], in Bangladesh in 1995 and 1999 [32, 33]; Demographic and Health Surveys (DHS), supported by the US Agency for International Development (USAID), in Nepal in 1996 [34], the Philippines in 1998 [35], and India in 1999 [36]; and an evaluation survey carried out by the Ministry of Health and UNICEF in Sri Lanka in 1997 [37] using methods similar to the MICS [31]. Data collection and initial treatment were as described below. All analyses were done with SPSS (versions 8 to 10).

Bangladesh

Multiple indicator cluster surveys (MICS) in Bangladesh were carried out in 1995 by the Bangladesh Bureau of Statistics (BBS) and in 1999 by the Institute of Public Health Bangladesh, both with UNICEF support. The general guidelines and a description of the methods for these surveys can be found elsewhere [32, 33]. The samples were designed to be self-weighting at the district level. Segments of each sample cluster were selected, within which all households were enumerated, as described in the UNICEF MICS survey methodology [31]. The 1995 survey (October–November) covered 39,000 households in 975 clusters. Three questionnaire forms were used, giving information for three data files, referring to individual preschool children (0–5 years) (file A), school-age children (5–15 years) (file B), and mothers and household characteristics (file C). Selected variables were merged from these to create a working file for analysis at the child level, with 17,808 cases with valid mid-upper-arm circumference values. Most data errors had been removed in the primary analysis, and only minor cleaning, including recoding of missing values, was required.

The variables used in the child-level analyses are listed in table 1, section A; these were selected during analysis from a larger set of variables. Mid-upper-arm circumference was the only child anthropometric measurement performed. Iodine in salt was estimated with standard UNICEF test kits [38], and the content was recorded as above or below 15 ppm. Socioeconomic and environmental variables with multiple categories were recoded to give a series of 0–1 dummy variables for each category.

The 1995 data were first analyzed at the district level, which had been computed from the child file [32]. Data were re-entered from the published tables. There were 64 rural districts (urban data were not available), with variables expressed as percentages (e.g., percentage of households with a certain type of latrine). For 1999, only district-level data were available and analyzed. These data were entered from the *Progotir Pathey* report [33] and yielded 76 cases. Because data on household size and population density were not available for 1999, the 1995 values were used for analysis. Unlike the 1995 data, both rural and urban districts were included in the 1999 sample, but only rural districts were included in the analyses for comparability. The variables used are listed in table 1, section B. The results in table 2 are derived from the 1995 and 1999 district-level data.

India, Nepal, and the Philippines

Data for Nepal, India, and the Philippines were obtained from Demographic Health Surveys for the years 1996, 1999, and 1998, respectively [34–36]. Data were available at both the household and the child level. Child- and household-level files were merged for each of these countries, and the cases were matched on key case and household identification variables. The merging of files yielded child-level datasets with 1,044 cases for India, 3,642 for Nepal, and 4,339 for the Philippines. Data treatment was similar to that for the Bangladesh child-level file.

Data for India and Nepal included the variables given in table 1, sections C and D. The India dataset was from Andrha Pradesh State, to which all the results from India refer. The ecozone of residence in Nepal was used to divide the dataset, which had national

TABLE 1. Variables used in analyses

A. Bangladesh B child level file (1995).

Mid-upper-arm circumference (*MUAC*), age, age squared (*age2*), gender, salt iodated (≥ 15 ppm, *hhiod*), latrine: water seal (*latws*), water supply: tap (*dwtap*), use of antenatal care (*anc*), literacy (district level variable included in child file, % who can write (*lit*)), housing: new brick (*rfbrn*), urban/rural (*durban*).

B. Bangladesh B district level (1995 and 1999).

Prevalence of AC < 12.5 cm (*acprvfm*), % households using iodated salt (*hhiod*), % children immunized against measles (*meas*), household size (*hhsize*), % houses with tin roof (*roofi*), % households using soap for handwashing (*handsoap*), population density (*popdens*).

C. India

Weight-for-age Z score (*wasdch*), age (*agemonth*), age squared (*agesqu*), gender (*genderf*), water: public well or pump (*dwat2c*), public pipe (*dwat4c*), latrine (none, *toiletdi*), scheduled group (*dethnic1* or *2*), salt ≥ 30 ppm (*salt30*), salt iodine content (0-7-15-30 ppm) (*sh023*), respondent (*v150*, 2 = wife), BMI of respondent (*v445*).

D. Nepal

Weight-for-age Z score (*wasdch*), age (*agemonth*), age squared, gender (*genderf*), water: well or pump in house (*dwat3*), public well or pump (*dwat4*), latrine: flush or pan (*dlat1*), pit (*dlat2*), education none or primary (*educdib*), salt ≥ 30 ppm (*salt30*), salt iodine content (0-7-15-30 ppm) (*sh023*), respondent (*v150*, 2 = wife), BMI of respondent (*v445*), eco-zone (mountain, hill, terai).

E. Philippines

Education (*v106*), electricity in house (*v119*), urban/rural (*v025*), region (*v023*), iodine capsules (*s413b*), salt 0 ppm (*dsalt1*), salt iodine content (0-7-15-30-75 ppm) (*saltcont*), birthweight (*birthwt*).

F. Sri Lanka

Weight-for-age Z score (*waz*), age (*agecl2*), age squared, birthweight (*bwtcl*), water: tube well (*dtube*), latrine: pit (*dpit*), waterseal (*dseal*), gender (*q604*), salt used with iodine ≥30 ppm (*iodhi*), breastfed at 4 months (*bf4month*).

Summary of availability of anthropometric and iodated salt variables

Country	Birthweight	Child anthropometry	Age range (mo)	Maternal BMI	Salt iodine	Survey
Bangladesh	No	Mid-upper-arm circumference	0–60	No	0, 15 ppm	MICS, 1995, 1999 [32, 33]
India	No	Weight, height, age	0–36	Yes	0, 7, 15, 30 ppm	DHS, 1998 [36]
Nepal	No	Weight, height, age	0–36	Yes	0, 7, 15, 3 ppm	DHS, 1996 [34]
Philippines	Yes	None	Not applicable	No	0, 7, 15, 3, 75 ppm	DHS, 1998 [35]
Sri Lanka	Yes	Weight, height, age	0–36	No	0, 15, 30 ppm	MICS, 1997 [37]

TABLE 2. Relation between the prevalence of low mid-upper-arm circumference (< 12.5 cm) at the district level in Bangladesh and the percentage of households using adequately iodated salt (> 15 ppm) after controlling for potential confounders[a]

	Coefficient, unstandardized (*t*)			
	1995 survey		1999 survey	
Variable	1a	1b	2a	2b
Households using iodated salt (%)	–0.107 (–3.910)**	–0.09981 (–3.794)**	–0.04502 (–2.306)*	–0.04293 (–2.000)*
Children immunized against measles (%)	—	–0.03745 (–0.879)	—	–0.04197 (–1.245)
Population density (no. of people/km^2)	—	–0.001784 (–1.465)	—	0.00003131 (0.039)
Household size (no. of people per household)	—	2.388 (1.406)	—	1.892 (1.705)
Houses with tin roofs (%)	—	0.0182 (0.632)	—	0.009285 (0.467)
Households using soap for handwashing (%)	—	0.143 (3.738)**	—	–0.05883 (–0.467)
Constant	14.811 (11.592)**	2.057 (0.205)	9.270 (7.037)**	1.513 (0.248)
N	64	63	64	64
Adjusted R^2	0.185	0.398	0.064	0.056

a. The unit of analysis is the district (regression ordinary least squares). Dependent variable: prevalence of mid-upper-arm circumference < 12.5 cm.

* $p < .05$.

** $p < .01$.

Source: UNICEF-supported multiple indicator cluster surveys (MICS) in 1995 [32] and 1999 [33].

coverage. Child anthropometric data (weight-for-age, weight-for-height, and height-for-age Z scores) were available. The respondent body mass index (BMI) was taken as maternal BMI when the respondent was the wife in the household. Even if there was some misclassification here, it is likely that BMI is correlated between household members. Iodine in household salt was estimated at four levels (0, 7, 15, or 30 ppm) by the starch colorimetric test, matching colors to a key provided. Anthropometric Z scores greater than 4.0 standard deviations and less than –4.0 SD were set to missing.

The Philippine national survey [35] reported on whether iodine capsules were received during pregnancy. No child anthropometric data (weight-for-age, weight-for-height, height-for-age) were collected for this survey; birthweight, however, was assessed by recall and was available for analysis in the dataset. Those with birthweights less than 1,500 g or more than 5,500 g were excluded from analysis. The iodine content of salt was coded as 0, 7, 30, and 75 ppm. The variables in the Philippines dataset are shown in table 1, section E.

Sri Lanka

The Sri Lanka data come from a baseline survey carried out for the Participatory Nutrition Improvement Project (PNIP) [37]. Survey samples were drawn from nine districts in three geographic areas that covered most of the country except the most northern areas, which were inaccessible because of conflict. Weight-for-age was measured on 1,033 children 36 months of age or younger. Birthweight, by recall, was recorded for 1,102 cases; selecting children 12 months of age or less gave 319 birthweight values. The variables used are given in table 1, section F. Iodation of salt was tested by assay, where no color = 0 ppm, light blue = 15 ppm, and dark blue = 30 ppm. Children with birthweights less than 1,500 g or more than 5,500 g and those with weight-for-age Z scores less than –5 SD or more than 5 SD were excluded from the analysis.

Analytical methods

The anthropometric and salt iodine data available are summarized in table 1. Anthropometric indices (weight-for-age, weight-for-height, and height-for-age) were calculated by using the National Center for Health Statistics (NCHS) standards. These were used as continuous variables (e.g., as weight-for-age Z scores) in analysis of child-level data, with prevalences of less than—2 SD also computed primarily for data presentation. The Bangladesh district data (1995 and 1999) were provided with prevalences of low mid-upper-arm circumference of less than 12.5 cm, which were retained. Iodated salt was assessed with the cut-points shown in table 1 (last section). In most cases, the relation of salt iodine levels with anthropometric data was nonlinear, so that the variable was dichotomized for most analyses, with 30 ppm as the cut-point (≥ 30), except for Bangladesh, where only values above or below 15 ppm were originally recorded. The ages of children were recorded in months (see table 1 for ranges). Age squared was included in regressions to allow for nonlinearity.

From the 1995 district data in Bangladesh, it was observed that the relation of low mid-upper-arm circumference with the use of iodated salt was clustered geographically in the center and east of the country, although no explanation for this could be found in the data. Therefore, distinction by area was also looked for in the other datasets. No clustering was seen in India (Andrha Pradesh). In Nepal, the association with anthropometry was found in the terai (foothills) as compared with the mountain and hill regions; the results below apply to the terai region (tables 4–7, discussed in the Results section). In Sri Lanka, most of the data on birthweight and anthropometry were from the northern and central provinces (Matale, Kurunegala, Puttulam, Anuradapura, and Pollonaruwa), where the association of anthropometric values with iodated salt was the strongest. The more southern districts of Ampara, Moneragala, Badulla, and Galle were also sampled; the applicable areas are noted in tables 4, 5, 7, and 8. In the Philippines, the results are distinguished (table 9) between the northern and central regions (regions I B VIII) and the others (E. Visayas, Mindanao: regions IX B XII).

Associations of anthropometry (including birthweight) with iodine were studied by tabulating unadjusted means, by regression (OLS) (tables 2, 3, 5–7), and by comparing means adjusted by analysis of covariance (tables 4, 8–10). The latter was used because the relationships were often nonlinear, the means being adjusted for the same confounders as in the regression analyses. The data points in figures 1 and 2 were plotted from the adjusted means calculated from the relevant analyses of covariance. The SPPS General Linear Model routine was used for analysis of covariance. The independent variables (e.g., for salt iodine, capsules in tables 9 and 10) were treated as fixed factors, confounders as covariates, the estimated marginal means output giving the means adjusted for covariates [39]. In tables 9 and 10 adjusted means by iodated salt category were estimated separately for with and without capsules, as these had a significant interaction.

Potential confounders were identified as those correlating both with the outcome and with the use of iodated salt. In the Bangladesh child-level dataset, with more than 17,000 cases, the criterion was a Pearson's correlation coefficient greater than 0.05, since many correlations were significant with this large a sample; in the other datasets, the criterion for inclusion was generally that the coefficient in the regression model was significant at $p < .05$. Interactions were examined by

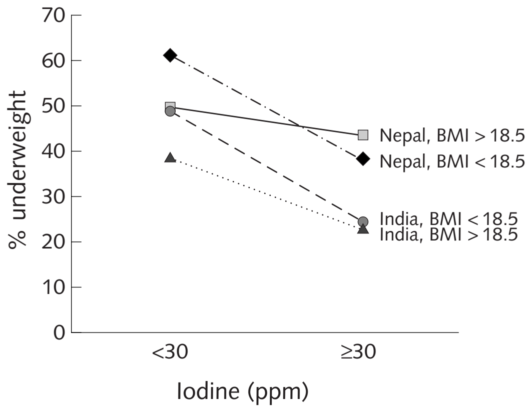

FIG. 1. Prevalence of underweight children in relation to iodated salt, controlling for maternal BMI

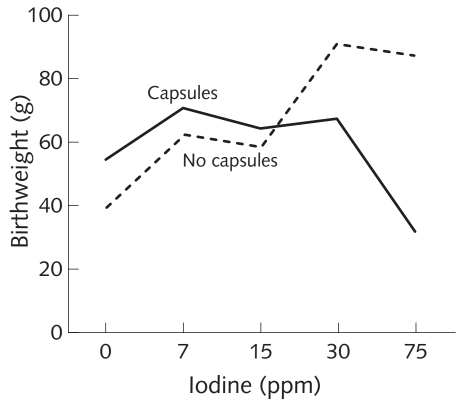

FIG. 2. Relation of iodated salt and iodated oil capsules in pregnancy with birthweight. Regression results: Dependent variable = birthweight (g). Coefficients: salt (0-7-15-30-75 ppm), B = 2.406 (t = 2.477, p = 0.013); iodine capsules, B = 40.261 (t = 1.663, p = 0.096); interaction, salt * capsules, B = -3.200 (t = -2.759, p = 0.006); controlling for urban/rural, education, electricity in house; constant = 3133.5, n = 3,853, adjusted R^2 = 0.004

regression, and again the interaction term—the product of the two independent variables—was included when $p < .05$, with both independent variables also in the model themselves (e.g., table 6).

A further step was taken with the Bangladesh child-level dataset to check for confounding by unobserved variables, using a two-stage instrumental variable approach to control for unobserved determinants of both iodated salt use and mid-upper-arm circumference. This estimation procedure, which is widely used in the economics literature [40, 41], consists of estimating an iodated salt use equation, using the results to predict iodated salt use, and then estimating an arm circumference equation using the predicted value as an independent variable. In order to identify the model, a series of dummy variables were used indicating the geographic location of the child in the iodated salt use equation, but not in the arm circumference equation.

Interactions with maternal BMI (table 6) and with iodated salt and capsules (fig. 2) were studied by regression; the interactions seen in figure 1 were tested for significance, as shown in table 6.

Results

Association of mid-upper-arm circumference with iodated salt (Bangladesh)

The geographic distribution of child malnutrition within Bangladesh was initially studied as part of a national exercise to identify investment opportunities for improving child nutrition [30, 42], for which data from a 1995 UNICEF-supported survey were available [32]. In this survey, child malnutrition was assessed from mid-upper-arm circumference measurements, and the data were provided at the district level (n = 64). A number of socioeconomic and environmental variables were included. Samples of household salt were tested for iodine content [32], and the results above an estimated 15 ppm were recorded as positive. Since iodine deficiency can affect growth, at least when it is severe, we investigated the association of the percentage of households using iodated salt with the prevalence of low mid-upper-arm circumference (< 12.5 cm). The association was significant ($p < .001$), with a higher percentage of households in the district using iodated salt corresponding to a lower prevalence of low mid-upper-arm circumference (table 2, column 1a).

Such associations, particularly at the aggregate level, are vulnerable to confounding, for example, by districts with higher socioeconomic status (SES) having better access to iodated salt and lower malnutrition. Potential confounders were identified as those having a significant Pearson's correlation coefficient ($p < .05$) both with the percentage of households using iodated salt and with the prevalence of low mid-upper-arm circumference. The variables that met these criteria were the percentage of children with measles immunization, household size, and hygiene assessed as the use of soap. The results, with control for these potential confounders, are shown in table 2, column 1b. The size and significance of the coefficient of correlation for the percentage of households using iodated salt with the percentage of low mid-upper-arm circumference as the dependent variable is essentially unchanged, at approximately 0.1% ($p \leq .001$); this means that for each percentage point of increase in the proportion of households using adequately iodated salt, the prevalence of low mid-upper-arm circumference is reduced by 0.1 percentage point. To illustrate this, the average prevalence of low mid-upper-arm circumference is 12.5% for the group of districts with fewer than 20% of households using iodated salt (n = 13), as compared with 6.1% for those in which more than 65% of households use iodated salt ($n = 11$); the intermediate group, in which 20% to 65% of households use iodated salt ($n = 40$), has a 10.9% prevalence of low mid-upper-arm circumference.

Subsequently, a dataset from a similar survey carried out in 1999 was obtained [33]. The results of equivalent analyses are also shown in table 2, columns 2a and 2b. Again, the association of iodated salt with low mid-upper-arm circumference is significant and persists after potential confounders have been controlled for (models 1b and 2b). The coefficient is less, at a change in the prevalence of low mid-upper-arm circumference of approximately 0.04%; however, the mean prevalence of low mid-upper-arm circumference was also less by 1999, at 6.1%, so the coefficient is proportionally similar. Those groups with less than 50% of households using adequately iodated salt ($n = 8$) had an average prevalence of low mid-upper-arm circumference of 7.1%, whereas those in which more than 85% of households used adequately iodated salt ($n = 12$) had a prevalence of 4.5%; the extent of iodation was greater in 1999, so districts are grouped with higher cutoffs.

The original dataset from the 1995 survey was provided by the University of Dhaka, Institute of Statistical Research and Training. This contained 17,300 cases, from which the district-level indicators had been aggregated. The value of child mid-upper-arm circumference (in centimeters, for children aged 12 through 59 months) was used as the dependent variable. The use of iodated salt was now dichotomous, with a cutoff at 15 ppm of iodine. Age and gender, which were associated with mid-upper-arm circumference (but not with the use of iodated salt) were included, with age squared (to allow for nonlinearity). The association of mid-upper-arm circumference with the use of iodated salt was again highly significant (table 3, model 1), indicating an increase of about 0.3 cm for those using iodated salt. This corresponds to a mean mid-upper-arm circumference of 13.8 cm for the group using noniodated salt ($n = 10{,}318$), as compared with 14.1 cm ($n = 7{,}017$) for the group using iodated salt. This corresponds to a prevalence of 12.5% for a mid-upper-arm circumference of less than 12.5 cm versus 8.1% above 12.5 cm ($p = .00$); for a cutoff of 13.0 cm, the prevalence was 26.2% versus 19.6% ($p = .00$). The increase in mid-upper-arm circumference was similar, but not significantly different, for the groups 12 to 24, 24 to 36, and more than 36 months of age.

With this sample size, many variables were significantly associated with mid-upper-arm circumference. Potential confounders were therefore selected on the basis of their association with both mid-upper-arm circumference and use of iodated salt. Generally, those with a Pearson's correlation coefficient of at least 0.05 for both associations were selected. Where there were two dummy variables in the same group (e.g., house construction), the most highly associated are shown in table 3 for ease of presentation (additional dummies in the models did not change the conclusions). The results with mid-upper-arm circumference as the dependent variable are shown in table 3, model 2 (many intermediate models were also studied, with the same conclusions). The coefficient for iodated salt remains highly significant and is reduced in size to only a limited extent with the available potential confounders in the equation.

The results of the two-stage model to control for possible confounding by unobserved variables showed that the effects of iodated salt on mid-upper-arm circumference continued to be statistically significant, and in fact to be larger than the estimates reported above. This indicates that the coefficients for iodated salt shown in

TABLE 3. Relation between mid-upper-arm circumference and household use of iodated salt in Bangladesh for child-level data [32] after controlling for potential confounders

Variable	Coefficient, unstandardized (t, p) Model 1	Model 2
Use of iodated salt (> 15 ppm, dummy)	0.292 (17.75, 0.000)	0.212 (12.594, 0.000)
Age	0.0536 (16.05, 0.000)	0.0496 (14.197, 0.000)
Age squared	–0.000274 (–5.91, 0.000)	–0.000231 (–4.838, 0.000)
Gender	–0.208 (–12.89, 0.000)	–0.205 (–12.832, 0.000)
Urban location (dummy)	—	0.123 (3.874, 0.000)
Use of antenatal care (dummy)	—	0.00910 (3.946, 0.000)
Latrine (dummy) (water seal)	—	0.160 (5.679, 0.000)
Water supply (dummy) (tap)	—	0.241 (4.893, 0.000)
Literacy: % of subjects who can write a letter (district-level variable)	—	0.00321 (2.975, 0.003)
House built of new brick	—	0.455 (8.274, 0.000)
Constant	12.629	12.540
n	17,335	17,283
Adjusted R^2	0.179	0.198

table 3 may, if anything, be biased downwards because of unobserved determinants of mid-upper-arm circumference. These results give additional evidence that the association is not likely to be due to unmeasured confounding.

The findings showed that the presence of adequately iodated salt in the household was associated with an increase in mid-upper-arm circumference of about 0.2 to 0.3 cm in 12- to 59-month-old children. This did not appear to be due to confounding by SES or environmental factors included in the survey or, according to additional statistical tests, by unobserved variables.

Association of weight-for-age with iodated salt (India, Nepal, Sri Lanka)

Salt in survey households began to be tested for iodine as part of some DHS surveys in the late 1990s, and two surveys from India and Nepal were identified with data suitable for further investigation of the association of iodated salt with child anthropometry. Data from a survey in Sri Lanka were also available [43].

The associations of weight-for-age with iodated salt levels were investigated by tabulation and by regression, first removing only the effects of age and gender, then controlling for potential socioeconomic and environmental confounding variables. Table 4A shows the results as mean weight-for-age SD scores, and table 4B shows the results as prevalences of less than –2 SD. The results for India are from Andrha Pradesh. The terai region in Nepal was selected because the association with anthropometric values was seen only there and not in the hills and mountains (although the coefficient of correlation between the use of iodated salt and weight-for-age was significant in both cases: for terai, $p = .007$; for all areas, $p = .020$); the implications are discussed later. For Sri Lanka, the association was found mainly in the northern and central areas but was also seen overall (see table 8). The averages are first shown in table 4A as means adjusted for age and gender, then further adjusted for potential confounding variables; these were selected by regression analyses as those that remained significant in multivariable models (see below). The specific variables, which cover water and sanitation, education, ethnic group, and similar factors, are given in table 1. The pattern is similar for all three countries. The group with salt iodine levels of 30 ppm or higher consistently had a higher weight-for-age, and this difference remains significant ($p < .05$) after the available potential confounders have been controlled for (except for India, where $p = .096$). However, at lower levels of iodation (0, 7, and 15 ppm), essentially

TABLE 4A. Mean weight-for-age (0-36 months) according to salt iodine content, adjusted for age and gender, and for potential confounding variables, for India, Nepal (terai area), and Sri Lanka (North and Central)

Salt iodine (ppm)	India		Nepal (Terai)		Sri Lanka	
	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)
0	–1.671 (332)	–1.613 (328)	–1.943 (94)	–1.902 (91)	–1.567 (383)	–1.557 (378)
7	–1.649 (318)	–1.614 (318)	–1.961 (436)	–1.924 (433)	NA	NA
15	–1.630 (107)	–1.633 (107)	–1.821 (486)	–1.815 (479)	–1.645 (128)	–1.640 (122)
30	–1.184 (162)	–1.368 (162)	–1.666 (401)	–1.745 (389)	–1.270 (86)	–1.296 (86)
Total	–1.573 (919)	–1.572 (915)	–1.823 (1,417)	–1.835 (1,392)	–1.541 (597)	–1.536 (586)
F, P (salt)	9.507, 0.000	2.118, 0.096	7.262, 0.000	2.738, 0.042	4.034, 0.018	3.280, 0.038

TABLE 4B. Prevalence of low weight-for-age (< –2 SD, 0–36 months) according to salt iodine content, adjusted for age and gender, and for potential confounding variables, for India, Nepal (Terai area), and Sri Lanka (North and Central)

Salt iodine (ppm)	India		Nepal (Terai)		Sri Lanka	
	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)	Adjusted for age and gender only (*n*)	Adjusted for age, gender, and confounders (*n*)
0	39.4 (332)	37.1 (328)	58.3 (98)	56.1 (95)	37.6 (381)	37.2 (376)
7	41.5 (318)	40.3 (318)	52.8 (446)	51.8 (443)	NA	NA
15	38.8 (107)	39.0 (107)	46.5 (499)	46.4 (492)	37.6 (128)	38.0 (122)
30	19.0 (162)	25.7 (162)	40.6 (413)	43.1 (400)	21.7 (86)	23.2 (86)
Total	36.5 (919)	36.4 (915)	47.5 (1,456)	47.8 (1,430)	35.3 (595)	35.3 (584)
F, P (salt)	9.966, 0.000	3.284, 0.020	7.360, 0.000	3.879, 0.009	4.503, 0.011	.631, 0.027

no relationship is observed.

For further investigations using regression, the salt-iodation variable was collapsed into two categories, 0 through 15 ppm and 30 ppm or more. This dummy variable was significantly associated with weight-for-age SD score in all three cases, with control for the confounding variables, as would be expected from table 4A.

The influence of the child's age on the apparent response to iodine was examined by running the regressions by age group, as shown in table 5. In all three cases, the coefficient was greatest and most significant in the 12- to 23-month age group and was less significant, or not significant, for the 0- to 11-month and the 24- to 36-month groups.

TABLE 5. Regression coefficients (boldface) for iodated salt (≥ 30 ppm) with weight-for-age SD score, according to age group, after controlling for environmental and socioeconomic variables (see table 1)[a]

Age group (mo)	Coefficient (unstandardized); T, P (*n*)		
	India	Nepal	Sri Lanka
0–36	**0.249** 2.517, 0.012 (915)	**0.124** 2.196, 0.028 (1392)	**0.344** 2.803, 0.005 (579)
0–11	**0.0259** 0.144, 0.100 (329)	**0.0837** 0.886, 0.376 (555)	**0.403** 2.010, 0.046 (194)
12–23	**0.399** 2.481, 0.062 (332)	**0.197** 2.151, 0.032 (493)	**0.633** 2.718, 0.007 (186)
23–36	**0.279** 1.543, 0.094 (254)	**0.0538** 0.492, 0.623 (344)	**0.0990** 0.461, 0.645 (199)

a. India, data from Andhra Pradesh; Nepal, Terai Zone; Sri Lanka, Northern and Central Districts.

Effect of maternal BMI on the relation of children's weight-for-age with the use of iodated salt (India and Nepal)

In the surveys from India and Nepal, the body mass index (BMI) of the respondent was measured, as well as the position of the respondent in the household. It was assumed that the wife was the mother of the child measured. These cases were selected, which reduced the sample size by about half but allowed investigation of the relation of child anthropometry with the use of iodated salt while taking account of maternal BMI.

Maternal BMI was significantly associated with child weight-for-age in both India ($r = 0.133$, $n = 449$, $p = .005$) and Nepal ($r = 0.219$, $n = 767$, $p = .000$). In India, but not in Nepal, BMI was also associated with the use of iodated salt (India: $r = 0.259$, $n = 529$, $p = .000$; Nepal, not significant). The dummy variable of 30 ppm or more for salt iodine was used, as discussed above, and BMI was kept as a continuous variable in the regression. The results are summarized in table 6. With weight-for-age SD score as the dependent variable, the interaction term of BMI and iodine was not significant and was excluded. Iodine in salt continued to be significantly associated with increased weight-for-age in both datasets (models 1 and 2). When a dichotomized variable for underweight (less than –2 SD weight-for-age, i.e., as used to calculate prevalences) was used as the dependent variable (models 3 and 4), the interaction

TABLE 6. Relation between child weight-for-age (0–36 months) and iodated salt, after controlling for maternal BMI, in India and Nepal: regression coefficients for weight-for-age SD score and prevalence of < –2 SD[a]

	Coefficient, unstandardized (T, P); model no.			
	Weight-for-age SD score		Prevalence of < –2 SD	
Variable	India Model 1	Nepal Model 2	India Model 3	Nepal Model 4
Iodine level in salt ≥ 30 ppm (dummy)	0.391 (3.060, 0.002)	0.202 (2.800, 0.005)	–0.880 (–2.612, 0.009)	–0.755 (–2.478, 0.013)
Maternal BMI	0.0427 (2.449, 0.015)	0.103 (6.101, 0.000)	–0.0287 (–2.987 0.003)	–0.0456 (–4.854, 0.000)
Interaction, iodine*BMI	NS—see note	NS—see note	0.0344 (2.063, 0.040)	0.0327 (2.084, 0.037)
Constant	–1.110	–2.508	0.489	0.858
n	440	767	440	785
Adjusted R^2	0.195	0.286	0.140	0.200

a. Interactions not significant for weight-for-age (India, $p = .4$, Nepal, $p = .3$) and not included in model. Age, age squared, and gender are included in these models, coefficients not shown.
India, data from Andhra Pradesh; Nepal, Terai Zone; Sri Lanka, Northern and Central Districts.

term was significant (marginally for Nepal at $p = .055$), and overall the presence of iodine was associated with a lowered prevalence of underweight, after maternal BMI had been controlled for. Other potential confounders (e.g., water and sanitation, housing, and education) would exert their effect on child weight at least in part through maternal nutrition, and therefore it would not be ideal to include these in the models; when these were included, the coefficient of correlation of the use of iodated salt with weight-for-age was somewhat reduced ($p = .055$ for Nepal and $p = .026$ for India).

The prevalence of underweight relating to the use of iodated salt, within categories of maternal BMI, is plotted in figure 1. The prevalence values (i.e., the eight points plotted) were calculated as means for the groups defined by salt iodine and BMI. The interaction terms for BMI interaction with iodated salt (BMI*iodine) are significant, as shown in models 3 and 4 in table 6, and this is represented by the difference in slopes between BMI groups within country. The results shown in figure 1 indicate, first, that the risk of being underweight is lowered to a greater extent by the use of iodated salt in those children with malnourished mothers (BMI < 18.5) than in those with better-nourished mothers. Second, low maternal BMI is associated with increased risk of the child's being underweight *only* in the absence of iodated salt: the prevalences are not significantly different, within the Nepal or India data, for the higher maternal BMI-high iodated salt groups. Third, it should be noted that the size of the effect, in the group with low maternal BMI, is considerable: the use of iodated salt was associated with a reduction in the prevalence of underweight from 62% to 39% in the group in Nepal with BMI < 18.5 and from 49% to 25% in the group in India with BMI < 18.5

Relation of use of iodated salt to different anthropometric indices (India, Nepal, Sri Lanka)

The relation of iodine with weight-for-age is shown in table 5. Similar results for weight-for-height and height-for-age are shown in table 7. In Nepal and Sri Lanka, the association was strongest with weight-for-height, and the association with height-for-age was less significant or not significant. For the Indian data, the association with height-for-age was stronger than that with weight-for-height. Breaking these down by age was limited by sample size, but generally the pattern shown in table 5 was followed, with the 12- to 23-month age group showing the strongest association. In the Indian data, the association of the use of iodated salt with weight-for-height was seen in the 12- to 23-month age group only ($p = .07$), whereas the association with height-for-age was weaker, but over the larger age range of 12 to 36 months.

After control for maternal BMI (in India and Nepal), an examination of the relationship of iodine with weight-for-age, weight-for-height, and height-for-age within age groups yielded some further information. For Nepal, the strongest association was with weight-for-height and weight-for-age in the 12- to 24-month age group; the Indian data had similar associations and were also significant for the 24- to 36-month group.

The association of the use of iodated salt with child weight-for-age thus appears to be mainly due to an association with wasting after 12 months of age. This could nonetheless in part result from development *in utero*, where iodine is best established as having an effect on growth.

TABLE 7. Regression coefficients (boldface) for iodated salt (≥30 ppm) with weight-for-age, weight-for-height, and height-for-age, in children 0-36 months of age, after controlling for potential confounders (see table 1)[a]

Anthropometric measure (Z score)	Coefficient (unstandardized); T, P (*n*)		
	India	Nepal	Sri Lanka
Weight-for-age	**0.249** 2.517, 0.012 (915)	**0.124** 2.196, 0.028 (1,392)	**0.344** 2.803, 0.005 (579)
Weight-for-height	**0.101** 1.004, 0.316 (935)	**0.127** 2.377, 0.018 (1,430)	**0.355** 3.147, 0.002 (563)
Height-for-age	**0.203** 1.832, 0.067 (879)	**–0.069** –0.130, 0.891 (1,344)	**0.222** 1.756, 0.080 (560)

a. India, data from Andrha Pradesh; Nepal, Terai Zone; Sri Lanka, Northern and Central Districts.

Relation of the use of iodated salt to birthweight (Philippines and Sri Lanka)

Two of the available datasets (Sri Lanka and the Philippines) included estimates of the child's birthweight. Birthweight was estimated by recall at the time of interview, at which time the iodine content of salt was also measured. Thus, access to iodine in salt applies to the current time, not to the period when the child was *in utero*. For the Sri Lanka data, children aged 12 months or younger were selected, since narrowing the time since birth presumably increases the probability that the current access to iodine is like that in pregnancy. Table 8 shows the results for the overall areas surveyed and for the northern and central areas, where the association of the use of iodated salt with child anthropometric values was found. Children from households using adequately iodated salt had higher birthweights, a result consistent with the hypothesis that part of the effect of iodine on anthropometry occurs *in utero*. Examining postnatal growth with weight-for-age as the dependent variable and with birthweight included as an independent variable did not show any significant effect of iodine for any age group up to 36 months. The only significant association was that of weight-for-height at 6 to 12 months with iodine, after birthweight was controlled for (weight-for-height was not associated with birthweight, in contrast to weight-for-age or height-for-age, which were highly related).

About 65% of the mothers in the Philippines sample received iodated oil capsules during pregnancy. The association of birthweight with the use of iodated oil capsules and iodated salt was examined by analysis of covariance (table 9). The association of iodated salt with birthweight was significant in the north and central regions of the country (regions I–VIII) but not in the south (Mindanao). The measures of SES that were correlated with birthweight, use of iodated salt, and use of iodated oil capsules were included, and the mean values of birthweight adjusted for these are given in table 9. The lowest mean birthweight and the highest prevalence of low birthweight were in the group that did not use iodated salt or capsules. A significant increase in birthweight was associated with the use of iodated salt. However, children in the group using iodated salt and capsules had a *lower* mean birthweight than those in the group using iodated salt alone. These results are consistent with an increase in birthweight

TABLE 8. Relation of iodated salt to birthweight in Sri Lanka[a]

Salt iodine (ppm)	All areas			North and Central		
	Mean birth-weight (g)	% low birth-weight	*n*	Mean birth-weight (g)	% low birth-weight	*n*
< 30	2,776	23.3	278	2,749	26.4	180
≥ 30	2,943	14.2	44	3,007	12.3	36
Total	2,799	24.1	322	2,792	24.1	216

a. Birthweights adjusted for sanitation (dummies for water seal and pit latrines) and water supply (dummy for tubewell). Cases selected for children aged 12 months or less at time of survey. Analysis of variance for mean birthweight by iodine ≥ 30 ppm: all areas, $p = 0.038$; North and Central, $p = .004$. North and Central Districts: Matale, Kurunegala, Puttulam, Anuradapura, Pollonaruwa. All areas: North and Central plus Badulla, Moneragala, Ampara, and Galle.

TABLE 9. Relation of iodine to birthweight in the Philippines[a]

Salt iodine (ppm)	Iodine capsules	All regions			Regions I B VIII		
		Mean birth-weight (g)	% low birth-weight (< 2,500 g)	*n*	Mean birth-weight (g)	% low birth-weight (< 2,500g)	*n*
0	No	3,118	18.7	1,095	3,042	20.5	635
	Yes	3,163	14.6	1,890	3,116	16.7	983
> 0	No	3,228	12.9	281	3,253	8.1	143
	Yes	3,169	12.7	587	3,141	12.0	269
0	Both	3,148	16.1	2,985	3,089	18.3	1,618
> 0	Both	3,186	12.9	868	3,178	10.6	412

a. Mean birthweight and percent low birthweight adjusted for urban/rural location, educational level, housing with electricity, calculated separately with and without capsules. *Analysis of variance:*
For mean birthweight: all regions: without capsules, iodated salt, p=.021; with capsules, iodated salt, p=.85; regions 1B8: without capsules, iodated salt, p=.001; capsules, p=.58. For percentage with low birthweight: all regions: without capsules, iodated salt, p=.0325; with capsules, iodated salt, p=.238; regions I-VIII: without capsules, iodated salt, p=.001; with capsules, iodated salt, p=.064.

resulting from the use of iodated salt, although the relation with the use of capsules is surprising.

The role of iodated oil capsules can be further studied by disaggregating the salt iodine content, as shown in table 10 and figure 2. At salt iodine content levels of 0 and 7 ppm, the use of iodated oil capsules in pregnancy was associated with an increase in birthweight. However, at the higher levels, notably at 75 ppm, there appeared to be a negative effect of the use of capsules. The effect was significant, as the mean birthweight for the group using salt with 75 ppm iodine was nearly 200 g higher *without* capsules, after adjustment for SES variables (p = .017). Since 75 ppm is a high level of iodation that is now applied only where there is severe deficiency, it is conceivable that the use of salt iodated at this level, plus iodated oil in pregnancy, in fact had a negative effect on intrauterine development.

Discussion

In the Asian populations studied, child anthropometric values are associated with the use of iodated salt in the household by its effect on mild iodine deficiency. This has not been shown before in large-scale programs but is consistent with at least two trials using iodated oil in pregnancy [22, 23], as well as with the earlier demonstrations of the impact of iodine on severe deficiency [1]. The associations are complicated by several factors. First, the data are mostly cross-sectional, which allows only the comparison of current anthropometry with current access to iodine. Because body size is the result of earlier changes, the assumption had to be made that households using iodated salt at the time of the survey were more likely to have used iodated salt at an earlier time, and vice versa; departures from this add to the error. There was no additional information to allow control of this effect. Associations would be weakened by this effect, but there was no reason to suppose it created bias.

TABLE 10. Effects of different salt iodation levels and use of iodated oil capsules during pregnancy on birthweight in the Philippines (all regions)[a]

Salt iodine (ppm)	Birthweight (g) (n)	
	No iodine capsules	Iodine capsules
0	3,118 (1,095)	3,163 (1,890)
7	3,186 (95)	3,212 (185)
15	3,175 (30)	3,192 (75)
30	3,272 (72)	3,201 (132)
75	3,260 (84)	3,096 (195)

a. Means were calculated separately for series with and without capsules, with adjustment for urban/rural location (v025), educational level (v106), and electricity in house (v119). Regression results are shown in the footnote to figure 2.

Second, there is a likelihood that households using iodated salt are more accessible and have better socioeconomic and environmental conditions, which in turn favor better anthropometric indices in children. This potential confounding was extensively investigated. A number of factors measured (e.g., hygienic practices in Bangladesh) were associated both with anthropometric measurements and with the use of iodated salt. However, the relationships of anthropometry with iodine persisted when these potentially confounding factors were controlled analytically by regression, as well as by stratification (results not shown here). The regression coefficients were decreased somewhat (see tables 2 and 3) with all available potential confounding variables in the model, but they remained highly significant, and the coefficient size tended to stabilize after the first one or two control variables had been entered. The association with iodine was, moreover, among the strongest seen with any variable. Analyses by category of iodated salt, using mean anthropometric indices (including birthweight) and prevalences below cutoffs, adjusted for confounders (as in tables 4, 8, 9, and 10), confirmed these results. Maternal BMI is causally related to many socioeconomic and environmental variables, as well as to child anthropometry (notably through birthweight); again, associations of iodine with anthropometry remained significant after control for maternal BMI, with interesting interactions that are discussed below. Econometric methods used to allow for confounding by omitted variables in the Bangladesh data produced, if anything, stronger relationships. Thus, the associations reported are unlikely to be due to confounding, and given the plausible mechanisms, the conclusion is drawn that household use of iodated salt may result in better anthropometric indices in children.

Third, a number of factors appear to modify the association of iodine with child anthropometry. The relationship is not the same in all locations or all groups. Geographic clustering appeared when the associations were mapped for Bangladesh, i.e., as anthropometry/iodine regression coefficients estimated within areas. Mapping by district showed that the association occurred mainly in the center and center-east of the country; additional variables were not available in the dataset that explained this finding. However, a large part of the water supply is known to be heavily contaminated with arsenic, particularly in the central-south section of the country [33, p. 39]. Arsenic inhibits the function of selenium, which is essential for the metabolism of thyroid hormones [3, 44–46]. Further research into this potentially complex relationship is needed.

In Nepal, the association of iodine with anthropometry was significant in the terai region (the foothills), but not in the mountains and hills. In the 1998 national survey [47], the goiter rate among women was higher in the mountains (61%) than in the hills and terai (49%); in school-age children, the difference was less marked. Urinary iodine showed the reverse, with low iodine excretion indicating more deficiency in the terai. For example, the prevalence of values less than 100 µg/L among women was 58% in the terai and 30% to 32% in the hills and mountains. Urinary iodine reflects current intake, including intake from salt (although the use of iodated salt is much the same in the different areas; estimates are similar in the national survey and the dataset analyzed here). The extent of the deficiency did not appear to be related to differences in the association of iodine with anthropometry in the other countries, nor in any clear way in Nepal, and other explanations for the variation were considered. Selenium deficiency occurring with iodine deficiency at higher altitudes is one possible explanation [48] (personal communication, Michael Golden, University of Aberdeen, 1996). Low selenium intakes and status have been recorded in Nepal, but they are not differentiated by area [49].

In Sri Lanka, the association clusters in the northern and central districts. Differential geographic occurrences of iodine-deficiency disorders have been observed, and they are thought to be related to the bioavailability of selenium and iodine in the soil [50]. In the Philippines, the associations were strongest in the northern and central regions, but available data did not suggest the reason for this. These geographic differences do not appear to be directly related to variations in iodine deficiency (as indicated by goiter) between areas. Overall, the association of iodine with child anthropometry is clustered in broad geographic areas, but the distinctions between these that cause the clustering have not been identified. In Bangladesh, Nepal, and Sri Lanka, interaction with other elements (selenium and arsenic) that can affect the conversion of iodine to the biologically active forms seems a plausible explanation and is open to further research.

The nonlinear relation of anthropometry with salt iodine levels (e.g., as seen in table 4) is in line with expectations for an S-shaped dose-response relationship. Low levels of iodine in salt do not reverse the deficiency until a threshold is reached. The varying level of salt iodation at which the response starts presumably reflects local conditions, including other sources of iodine. The higher end is possibly seen in figure 2, with the flattening of birthweight (among children of mothers not receiving capsules) above 30 ppm.

The size of the effect was substantial and fairly consistent between countries. For example, the difference in prevalence of low weight-for-age between the lowest and highest salt iodation levels was 11 percentage points in India, 13 in Nepal (terai), and 14 in Sri Lanka (North and Central) (table 4B). The incidence of low birthweight was 9 to 14 percentage points lower in Sri Lanka (all regions, North and Central; table 8) with iodated salt (an increase of 167 to 258 g). In the Philippines (table 9 and fig. 2), without iodated oil capsules the difference in the prevalence of low birthweight was 6 to 12 percentage points, an increase of 110 to 211 g (table 9); capsules without iodated salt produced a difference in the incidence of low birthweight of about 4 percentage points, from 45 to 76 g; with iodated salt and capsules, there were different effects that will be discussed later. The increase in birthweight of 110 g is similar to that observed by Anwar et al. [23], who gave iodated oil capsules to pregnant women in Bangladesh.

Two questions arise: whether these effects take place *in utero*, during postnatal growth, or both; and whether they are exerted on linear growth, soft tissue, or both (moreover, whether they are perhaps different at different stages of growth). In severe maternal deficiency, the fetus is stunted, leading to dwarfism; the effects of a mild deficiency on stunting are less known, although they are likely [21]. On the other hand, there was a reduction in infant and child mortality with iodine supplementation in Indonesia [24]. This suggests an effect on morbidity, presumably involving the immune response, which in the short term would translate into loss (or absence of formation) of soft tissue, seen as wasting.

Disaggregating the associations of iodine with weight-for-age into the components of height-for-age (stunting, linear growth) and weight-for-height (wasting, soft tissue) indicated that in Nepal and Sri Lanka the association with weight-for-height (table 7) was more significant than with the other indices. Only in Sri Lanka could postnatal effects be distinguished from birthweight by examining the regression coefficients separately within three birthweight categories (< 2.5 kg, 2.5-3.0 kg, > 3.0 kg); in the medium-birthweight group, the coefficients for weight-for-age and weight-for-height were significant ($p = .05$). This provides some evidence that iodine affects the postnatal growth of soft tissue or prevents wasting, possibly by reducing morbidity, which is normally correlated with wasting. In India, the association was more with height-for-age than with weight-for-height (although the association with weight-for-height was somewhat significant in the 12- to 23-month group). In India, the association of iodine with weight-for-age was observed from 12 months on, whereas in Sri Lanka it was seen from 0 to 23 months and in Nepal from 12 to 23 months (table 5). These differences cannot be explained at present.

Generally, the association of weight-for-age with iodine is strongest in the 12- to 23-month age group (table 5). This again argues for an influence of iodine separate from that through birthweight, because it reappears after infancy. This would be in line with iodine having an effect through immunity, since the child is exposed to increased infection after about 6 months, at which age maternally derived immunity is being lost. The greatest vulnerability to infection is in this 12- to 24-month age group. The effect seen on wasting is consistent also with immunity and infection as a mechanism: wasting usually correlates with intercurrent sickness, whereas stunting correlates well with socioeconomic factors, and hence so does weight-for-age, of which height-for-age is the main component [51].

The best-established association of iodine with anthropometric data is for *in utero* effects. Two of the datasets contained birthweight data. In the Sri Lanka survey, birthweight was determined by recall at the time of interview and thus could be only indirectly associated with the use of iodated salt. Minimizing the time distance means selecting younger children. A significant relationship was found with the use of iodated salt (see table 8) and a greater increase in birthweight (around 170–260 g), as compared with the intervention trial results in Bangladesh (110 g) [23]. The overall results were similar in the Philippines, but they were complicated by the use of both iodated salt and iodated oil during pregnancy. The likely interpretation of the results shown in figure 2 and table 10 is that, with low salt iodine, supplementation with iodated oil increased birthweight by about 50 g. In the absence of iodated oil, adequately iodated salt (≥ 30 ppm) increased birthweight by about 150 g, a result in line with results from elsewhere. However, with the use of both iodated oil and salt with high levels of iodine (75 ppm), birthweight *decreased*. The difference in birthweight between users and nonusers of iodated oil within the group using salt with 75 ppm iodine is significant ($p = .019$). This may correspond to the concern by the World Health Organization (WHO) [29] that excess iodine during pregnancy could impair fetal and neonatal thyroid function through the Wolff-Chaikoff effect, in which excess iodine impairs the synthesis of thyroid hormones. Aside from this possible overdose effect, the results suggest that in these populations, where goiter is not very severe and cretinism is almost unknown, iodine may still have significant effects on intrauterine development. Moreover, these effects are likely to be seen in a substantial proportion of the populations: the size of the average difference in birthweight, on average, is considerable, and it is unlikely to be due to a very much larger difference in a small part of the population averaging out at this level.

The differential effects of these associations in India and Nepal, depending on maternal BMI (table 6 and fig. 1), could also be due to influences of iodine on prenatal and/or postnatal growth. These cannot be distinguished from the present data. However, the interactions, and the size of the associated effects, have considerable implications. The effect of iodine was much more apparent in the groups with low maternal BMI, in which it had a large effect on child anthropometry. Equally, maternal BMI had no significant relation to child anthropometry in the group with adequate iodine. Aside from other considerations, the existence of interactions such as these may help to explain why different associations are found in different areas and groups. For the group with low maternal BMI, iodine appears to protect against low birthweight, facilitate postnatal catchup, or both. If confirmed by longitudinal studies, this finding will have important implications. Considerable developmental retardation (in body size and probably in neurological development) in the most underweight children could possibly be prevented by ensuring adequate iodine, even with underweight or otherwise malnourished mothers.

Programmatic implications

If many children *in utero* and during early childhood show a response to iodine in terms of growth, this means that they and their mothers are at least mildly deficient in iodine. If there is a response in body size, there is likely to be a response in neurological development. The apparent response to intervention seen here supports the view that mild iodine deficiency may be very extensive, and thus lends weight to the assertion that many children today may be suffering from suboptimal intellectual development [3]. These results help to demonstrate the extent and location of the problem. The most important immediate priority for programs is to ensure adequate iodine intake in pregnancy and early childhood; it is not enough to wait for the use of iodated salt to spread or to assume that this will always be effective.

Renewed attention to iodine intake, especially in pregnancy, should involve more vigorous monitoring of salt, strengthening programs to include iodine in antenatal supplementation (e.g., in multiple micronutrients, as advocated by UNICEF [52]), and possibly reconsidering the use of iodated oil, where the provision of iodated salt cannot be assured. The birthweight results from the Philippines caution against the risks of excess iodine in pregnancy. This question needs further research. It is likely that the level of 75 ppm iodine in salt is high and that iodated oil supplements should not be used together with highly iodated salt.

The results suggest that other factors may interfere with the effect of iodine. In several areas, no relation of anthropometry to iodine was seen. This may be because of differences in iodine metabolism caused by other nutrients (such as selenium), inhibitors (such arsenic), and environmental factors that modify bioavailability. Selenium deficiency may coexist with iodine deficiency as a result of leaching from soils [48], so that provision of selenium with iodine might be considered in these areas. These findings also stress that only monitoring iodine in salt is not enough to ensure that the deficiency is overcome. Surveillance of program implementation and effects (measured by IDDs and possibly functional outcomes) needs to be routine, analogous to nutritional surveillance of general malnutrition [53]. This in turn needs some research into assessment methods. Thus there may well be causes of IDD beyond dietary iodine deficiency operating in Asia that need to be addressed concurrently for effective programs.

The interaction of the effects of maternal BMI and the use of iodated salt on anthropometric measurements (fig. 1) suggests that targeting the poorest and most wasted population groups for access to iodine may have a greater impact on iodine deficiency. Although universal salt iodation is a reasonable goal, getting to the results of that goal might be enhanced by deliberately targeting the effort to those with greatest potential for response. The relation of iodine to the prevalence of underweight, especially among thin mothers, may also contribute to understanding other phenomena, such as "the Asian enigma," which refers to the greater extent of growth failure in children than would be expected from socioeconomic, environmental, and health factors [54], with implications for preventing the intergenerational persistence of growth retardation via low birthweight.

Implications for research

These findings can be applied to current programs, but both further confirmation and follow-up leads would be beneficial. The results are based on observational data and secondary analysis, and specifically designed studies are now needed.

A first important need is to carry out prospective studies that include direct assessment of intellectual as well as physical development. These would be based on assessment of the effect of iodine programs as they progress, as natural experiments. Certain features of such studies can be determined from the results here, including where to place the studies geographically, what ages to include, emphasizing mothers with low BMI, and considering interactive factors, such as other deficiencies and inhibitors. Within these, biological mechanisms should be considered. These investigations should also aim to better identify functional measures and indicators of iodine deficiency, and their response to intervention, for application to surveillance systems.

A second research need is therefore to extend the epidemiological surveillance of these (and other) micronutrient-deficiency control programs to other areas and populations to ensure their general effectiveness. In part, it requires research to develop systems to obtain the necessary information and feed it into improving and sustaining effective programs. Some of the basis for this exists, with simple testing of salt iodine with kits [38] during surveys and within local programs.

Conclusions

Evidence has been presented that increased iodine intake from iodated salt leads to increased body size in infants and young children in large sections of the populations of four Asian countries. The implication is that if there is a physical developmental response, there is probably a response in terms of neurological development, or significant numbers of children today have suboptimal intellectual development because of uncorrected mild iodine deficiency. The effect is probably exerted both *in utero*, as a mild but not innocuous parallel to the well-known effects of severe iodine deficiency, and on postnatal development even in the second year of life, possibly mediated through immunity. These conclusions are in line with some other studies showing a birthweight response to maternal supplementation in Bangladesh [23] and Algeria [22] and a reduction in child mortality (and presumably in at least severe morbidity) in Indonesia from child supplementation [24].

A number of interactions were identified: first, with geographic area, implying that other environmental factors modify the response to iodine; and second, with maternal BMI, the effect on child anthropometry appearing to be much greater in thinner mothers. A possible reduction in birthweight with the use of iodated oil supplementation in pregnancy together with highly iodated salt was observed in one case. Thus, care is needed in implementing iodine programs to ensure that the expected effect is not modified by other factors and to target these to the most generally malnourished populations.

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International Workshop on Multi-Micronutrient Deficiency Control in the Life Cycle, Lima, Peru, May 30–June 1, 2001

Rainer Gross, Archana Dwivedi, and Nevin Scrimshaw, editors

Key words: micronutrients, deficiency, life cycle

Abstract

Thirty-one representatives from international organizations, nongovernmental organizations, government agencies, universities, and the private sector participated in a three-day workshop in Lima, Peru, organized by the Universidad Nacional Agraria La Molina and supported by the Ministry of Health Peru, UNICEF, and the World Health Organization. The objective of the workshop was to develop a protocol for a comprehensive micronutrient supplementation program for populations in developing countries that suffer from deficiencies of several micronutrients. The workshop consisted of two components: presentation of preliminary results of the multicenter study on infant supplementation and recommendations on the policy and community, monitoring and impact evaluation, and research aspects of supplementation programs. This paper provides the summary reports of the second component.

Background

A series of workshops were held in the past two years to foster multi-micronutrient supplementation and fortification. Based on the ideas discussed in the workshops, several multi-micronutrient supplementation trials have been conducted, which provide information on efficacy in different age groups. It is time to reflect on the results of these trials and explore the lessons learned from these experiences to develop a comprehensive multi-micronutrient supplementation program addressing deficiencies in different age groups based on the life-cycle approach.

Objective

The objective of this technical workshop was to discuss the elements of a comprehensive micronutrient supplementation program for populations in developing countries that simultaneously suffer from the deficiency of several micronutrients. In particular, its purpose was to:

» present, analyze, and discuss the results of the international research on infant supplementation (IRIS) 1 multicenter study;
» present, analyze, and discuss the studies on the relative bioavailability of the multi-micronutrient supplement used in the IRIS 1 study;
» define the multi-micronutrient dosing for supplementation of all age groups within the context of the life-cycle approach;
» formulate indicators for monitoring and evaluating multi-micronutrient supplementation programs;
» formulate a protocol for a comprehensive multi-micronutrient supplementation program based on a life-cycle approach to be tested in different settings.
ignore dashed lines above

Program of the workshop

Thirty-one experts from 13 countries of South and North America, Asia, Africa, and Europe, working for international agencies (IAEA, UNICEF, GTZ, and USAID), governmental organizations (Peru, South Africa, and Vietnam), universities (Brazil, Germany, Peru, UK, and USA), nongovernmental organizations (AJCN, USA; CeSSIAM, Guatemala; Instituto de Investigación Nutricional, Peru; MI, Canada; and Nutrinet, France), and five specialists from the private sector (Chile, Peru, and Switzerland) came together from May 30 to June 1, 2001, in Lima, Peru, to discuss

Rainer Gross, is Chief, Nutrition Section, Programme Division, UNICEF, New York. Archana Dwivedi is Project Officer, Nutrition Section, Programme Division, UNICEF, New York. Nevin Scrimshaw is Senior Advisor, United Nations University Food and Nutrition Program (UNU), Boston, Mass., USA.

recommendations for micronutrient supplementation. The workshop was organized by the Universidad Nacional Agraria La Molina and supported by the Ministry of Health of Peru, UNICEF, and the World Health Organization (WHO). The workshop consisted of two components. In the first, preliminary results of the multicenter study IRIS 1 were presented and discussed. In the second part, three working groups were formed to discuss recommendations for future studies and interventions in the field of multi-micronutrient supplementation. Group 1 focused on community and policy aspects, group 2 discussed monitoring and impact evaluation issues, and group 3 deliberated over research needs. The results of each working group were presented and discussed. The rapporteurs considered additional comments from the plenary session in their final version of the report. The results of these three working groups follow.

Report of the Community and Policy Working Group

Rapporteurs: Eric Boy and Nevin Scrimshaw

Introduction

» In almost all developing countries, significant problems of multiple micronutrient deficiencies occur in children 6 to 24 months of age that urgently need attention. By this age the iron stores of the infant are depleted, and the breastmilk can no longer supply sufficient iron.

» Multiple fortification of cereal flours and other foods benefits older children and adults but does not sufficiently benefit this age group. The failure to provide additional iron at this critical age can have permanent adverse consequences for the cognitive development and education of the child.

» The child is growing rapidly at this age and needs a balanced complement of micronutrients not provided by the complementary feeding practices of lower-income mothers in most developing countries.

» Unless the mothers can afford fortified complementary foods, supplementation is the only feasible approach.

» Activities focused on the mothers to improve the nutrition and health status of children aged 6 to 24 months should not be neglected. Universal fortification of cereals with iron and selected other micronutrients will ensure a certain minimum level of iron status of the mother, but this should be complemented by supplementation of women of childbearing age to ensure that they enter pregnancy adequately nourished, and supplementation should be continued during pregnancy and lactation. In particular, adequate iron status of the mother is essential to ensure that the iron stores of the infant are sufficient for months, with exclusive breastfeeding as long as appropriate.

» For low-birthweight infants, iron supplementation may be required as early as two to three months.

» Other health interventions that benefit both the mother and the young child include spacing and limitation of pregnancies, environmental sanitation and hygiene to reduce enteric diseases, and treatment of malaria where it is endemic. Delayed ligation of the cord can significantly improve the iron stores of the infant. There are also many studies indicating that improving the general education and status of women in developing countries is an important measure benefiting the nutrition and health of all members of their families

» Successful implementation of such policies depends on effective monitoring and evaluation.

» While the deficiency of iron in this age group in developing counties is almost universal, and deficiencies of folate and zinc are recognized concerns, the young child should receive a balanced addition of micronutrients to his or her diet, because single nutrient deficiencies are rare. Moreover, as noted in the first IRIS workshop held in Rio de Janeiro in 1999, and still equally true, "Since operational strategies and distribution systems can be similar for each micronutrient, it is cost-effective to avoid duplication." Moreover, the incremental costs of additional nutrients are very small. Therefore, the workshop recommends the IRIS concept of multi-micronutrient intervention for children 6 to 24 months old.

» Since single deficiencies are rare, such a supplement should supply the most essential multiple micronutrients. Many different types of supplements can be used, ranging from liquids to powders to tablets and spreads. This is the IRIS concept.

» Preliminary findings from the IRIS I project have demonstrated in four different countries and cultural contexts the feasibility and acceptability of a friable tablet that can either be crushed and added to any food given to the child or broken into pieces and fed directly.

» It is not only a moral obligation of governments to address this problem, but also a legal obligation under the convention of "Rights of the Child," to which almost all countries subscribe. Moreover, the short- and long-term economic benefits of supplementation of this age group far outweigh the costs.

Need for situation analysis

» Determination that iron and a number of other nutrients are significant nutrition problems in a population.
» Agreement on the levels of each micronutrient in the supplement.
» How best to provide education, information, and communication to policy makers, implementers, and families as to the reasons for the urgency of interventions to improve the nutrition and health of this specific age group. It is essential that mechanisms for doing so be communicated and that the need for the recommended behavioral changes be recognized.
» How best to deliver a supplement to children 6 to 24 months old, and how to present it to the mother and child. It must be accessible, affordable, attractive, and safe. Hence, suitable packaging and instruction for its use are essential.

Policy problems and issues

» Choice of number and frequency of supplementations needs to be established.
» Lack of definition of the problem and priority for this neglected age group. Need to define and advocate for this target group.
» Better information on the timing and nature of complementary feeding is required.
» Need for flexibility of approach in the method of providing micronutrients to this age group.
» Need to better define the relation between the health and nutrition of the mother during pregnancy and lactation and the nutrition of the infant.
» Inadequate data for this age group because it is usually aggregated with that of older age groups.
» Need to ensure an adequate supply of whatever supplement is introduced and promoted and its uninterrupted delivery to distribution centers.

Implementation mechanisms

There is a great need for an institutional focus of responsibility. There needs to be an institution or organization designated as responsible for the implementation of a program for supplementation of children 6 to 24 months of age. This will vary among countries but is likely to be most effective when it is multisectoral and not limited to the health sector. Regardless of the administrative structure, it must have highly motivated leadership and political support. It must be capable of enlisting the support of all sectors involved, including local political authorities and communities.

It is essential that the community be enlisted in support of the program from its inception and convinced of its importance for the health and welfare of their children. The community should be given an opportunity to make the decision to implement the program and to play an active role in its promotion to families and in monitoring compliance. The support of community civil and religious organizations can sometimes be crucial. In some countries, nongovernmental organizations can play an important supporting role. In general, intervention programs of this type will fail unless they can enlist community support nationwide.

For any policy to be adopted by a government it must be presented at an appropriate time in the planning cycle.

Conclusions and recommendations

The studies in all four sites indicate that giving a multinutrient supplement weekly that provides two times the recommended daily allowance (RDA) results in an improvement in hemoglobin and anemia as compared with the placebo group. Although the response to daily supplementation with one RDA appeared to be greater in three of the four sites, daily supplementation costs more, and there is evidence from some countries that daily supplements are more difficult to distribute and to secure compliance with.

It is also recognized that supervised supplementation may not be fully applicable to the effectiveness of national programs because of cost and compliance. It is essential to determine whether the better response in hemoglobin response at three of the four sites with daily supplementation justifies the higher costs.

The working group concluded that in most countries, weekly distribution would prove feasible and sustainable for the reduction of iron deficiency. It will be important to assess the effect of the multiple micronutrient supplementation program on the status of other important nutrients measured as outcomes of the IRIS program.

The feasibility of cost recovery from the community or the family needs to be determined. In general, it is desirable to develop a system of cost sharing. Experience in some countries (Thailand, Vietnam, and Bolivia) indicates that this is usually feasible, improves compliance, and makes the program more politically acceptable and sustainable by reducing the cost to the government.

Monitoring and impact evaluation of a multi-micronutrient supplementation program

Rapporteurs: D'Ann Finley, Klaus Schümann, and Denise Hess-Bienz

Monitoring and impact evaluation, as defined in this workshop, occur after the efficacy and effectiveness of the multi-micronutrient supplementation program have been demonstrated and a large-scale intervention program has been implemented. If a preliminary program is being monitored, additional money must be allocated to evaluate whether the program should be scaled up to a full-scale program. In some places, the supply and distribution of supplements will be restricted to the public sector, whereas in others, some or all of this task will occur in the private sector. This workshop, however, was restricted to the public sector. If monitoring systems for other ongoing programs are already in place, these systems should be used, where appropriate, in order to make optimal use of resources and to simplify processes.

Policy review

The task of the monitors is to identify bottlenecks in the program and to flag them, i.e., to provide the information to the person in charge of the operation who can take appropriate action. The first monitoring step is to determine whether there is already a policy in place that will allow the implementation of the program, regardless of whether policies are implemented at a provincial or a national level. On a yearly basis, it is important to determine the extent to which the individuals responsible for implementation of the program are aware of these policies, and whether they understand them. It is also important to determine yearly whether the intervention program has been included in the appropriate budget and whether the necessary resources have been allocated in order to ensure continuing funding by the government. If an agency supports only the initiation of the supplementation program, it is important to determine who will take over support and monitoring of the program after the agency leaves.

Supply and distribution of supplements

Coverage is the percentage of the target group that receives the materials, and compliance is the percentage of individuals who consume the product in the specified amounts. Adequate coverage is the final consequence of a well-functioning supply and distribution system and should be monitored. Compliance can be checked by surveys on representative subgroups of the target group. The ordering of the product needs to be monitored. Key questions include: Is there a plan for ordering and requisitioning the supply according to need? Is the supply central or provincial? How much needs to be ordered? Was the amount ordered actually delivered?

The stock must be controlled for quantity and quality, whether it is kept on a central or a provincial level. To certify the content and quality of the micronutrients in the product is the manufacturer's task. The storage conditions should be monitored to identify any potential detrimental effects on the product. The supply itself has to be monitored for expiration dates, and any outdated stock has to be destroyed. Finally, the transportation of the supply and its dispensation to the place of use, for example, a health center, has to be monitored. Storage time and conditions at the place of use should also be monitored.

Each program needs a monitoring system, but this system needs to be supervised as well. The supervisor must check whether requisition forms are available where needed and whether they are completed accurately.

Training and education

Each aspect described above for monitoring the distribution of the product also applies to monitoring the training of the people engaged in the distribution of the supplement. This consists of information, education, and communication (IEC). Important questions in this respect are: Is there an adequate budget? Are the training materials available? Are they distributed? The IMCI (Integrated Management of Childhood Illness) system is an example of a system that monitors the delivery of services and the performance of staff in immunization programs.

The target population, including the caregiver, should receive information and education on the benefits of the micronutrient supplementation program, e.g., by use of social marketing techniques. The goal is to create a "push and pull" situation. A demand for the supplement from a well-educated population is an important part of the success of an intervention program and represents the "pull" part of the distribution process; availability and adequate supply represent the "push" part, since success is finally dependent on behavioral changes in the population.

Surveying changes in behavior and biochemical indicators

Valuable information on the general nutritional situation in a locality can be obtained from a variety of sources, such as the number of cases of severe anemia admitted to the hospital or the change in prevalence of overt clinical signs and symptoms. However, it seems very difficult, if not impossible, to disentangle the impacts of different programs that are simultaneously active at a given site or within a given population. The same holds true for the impact of events outside of these programs, such as droughts, changes in the economic situation, or political events. Therefore, trying to assign a specific change in behavior or in a biochemical indicator to a particular program is fraught with hazards.

In order to be able to monitor change, either in behavior or in biochemical indices, it is important to have baseline data available. Ideally, for a compliance survey the individuals initiating the program would do a baseline survey before the program started and a follow-up survey after it has been in effect for a long enough time that one would expect to see results. However, the costs and availability of facilities to do a specific baseline survey for a program are important constraints. Therefore, any available source of data should be evaluated for its usefulness as a baseline.

Usually baseline surveys have been done to provide evidence that the program is needed and to justify its initiation. Demographic and Health Surveys (DHS), Expanded Program of Immunization (EPI) surveys, and National Nutrition Surveys (NNS) are done in many countries on a routine basis. If possible, the individuals initiating the program should coordinate with one or more of these surveys in order to maximize the amount of information obtained. Therefore, a primary question is whether these survey data are available and current. If they are, the next question is whether they provide the necessary information to be used as baseline data for the program.

The ideal baseline survey would include three basic elements: anthropometry, a blood sample for analysis, and a questionnaire. Anthropometric data would be collected by standardized methods. The blood sample would be analyzed for variables of interest, such as hemoglobin, retinol, red blood cell count, zinc, ferritin, and markers of inflammation. The questionnaire should include questions on personal data, morbidity, and diet, and specifically for a micronutrient supplementation program, knowledge about micronutrient supplementation.

The follow-up survey would include the same three elements, and the questionnaire would be expanded to include questions on compliance and behavioral change. These questions would include the following: Did the mother or caretaker receive the supplement? Did she give it to the child? Did the child take it? What effect does the mother think the supplement will have on the child? Why does she think she should give it to the child? The questionnaire should also include questions about potential side effects of the program and the interaction of this program with other programs.

Conclusions

An important task of the monitoring and impact evaluation will be to communicate its results. Was the intervention program a success or a failure? What were the critical issues, particularly the problems encountered during the program with the policies, supply chain, compliance, and education? Only the effective communication of these issues to the appropriate audience will help future programs to be successful.

Report of the Research Needs Working Group

Rapporteurs: Jacques Berger and Noel W. Solomons

Introduction and approach to the task

The topic and context of the work of the Research Needs Working Group was the need for investigation of more effective impacts of multiple micronutrient interventions. The background for the discussion was the overview, technical information, and data presented in the International Workshop on Multi-Micronutrient Deficiency Control in the Life Cycle. Notably, the results in the multicentric IRIS (International Research on Infant Supplementation) were the immediate concrete context for discussion, but the group interpreted the mandate in a somewhat broader dimension.

At the applied investigation level, a number of descriptive terms (efficacy, safety, effectiveness, and efficiency) are commonly used. The working group began its deliberations by coming to a consensus on key working definitions. *Efficacy and safety:* Biological effect under controlled experimental conditions. *Effectiveness:* Effect in real-life situations. *Efficiency:* Ratio between results achieved and resources consumed.

With respect to the design for implementation of multi-micronutrient intervention programs, these critical parameters must be addressed both before and during the implementation and monitoring process.

As a second step, the working group set out in matrix format a potential agenda for discussion and "brainstorming" during the course of its deliberation. The notion was to have a focus on the consensus issues that the group's members as a whole considered relevant for discussion in order not to focus on a limited number of issues of importance for the research agenda. This set of principal terms and component terms is laid out in table 1.

Setting a research agenda

From definitions and brainstorming, the working group discussed the topics identified on the agenda. For each topic, we present the research questions identified and a justification for addressing them with continued investigation, as well as reflections on the topic by the group.

TABLE 1. "Brainstorming" agenda/matrix

Efficacy/safety
Dosing
Low birthweight
Pregnancy
Functional vs. biochemical outcomes
Disease issues
Bioavailability
Nutrient interaction
Food/carrier
Delivery issues
Vehicles
Fat
Powder vs. tablet vs. liquid
Bioavailability
Acceptability
Behavioral issues
Compliance
Cultural perception
Dosing schedule
Communication
Cost-benefit
Relation to efficiency
Affordability issues
Assessment
Magnitude and severity of different micronutrient deficiencies
Cutoff in different age groups
Need for new assessment methods
Intervention: biochemical outcomes
Intervention: functional outcomes/disease issues not attributable to single micronutrient: growth, morbidity, stress indicators: efficacy/safety

Dosing issues

The question identified as requiring research within this area is: Should the doses of micronutrients be linked to multiples of the RDA?

The justification for revisiting the use of RDA multiples for creating dosages in supplements has several facets. Some nutrients (e.g., calcium, zinc, and iron) are poorly tolerated in high multiples of the RDA, and even doses of two or three times the RDA may be difficult to swallow or tolerate in a supplement. Moreover, other nutrients, such as thiamin and vitamin C, are so poorly stored that high multiples will not be retained beyond the day of supplementation. Finally, even in developing countries, the background diet or setting can provide such abundant supplies of some nutrients, e.g., vitamin E from whole grains or oils and vitamin D from tropical sunshine, that no supplementation is needed.

The RDA levels blended across the nutrients represent a common balance among the different nutrients, reflecting the pattern in an appropriately balanced diet. A minority dissenting admonition was that high-multiple RDA formulations can be dangerous, especially adult RDAs when they fall into the hands and mouths of young children and are consumed accidentally.

Delivery issues

The group identified three levels of delivery issues:

» Food format. Is the supplement presented in a medicinal form, i.e., as a powder, elixir, pill, or tablet? Or is the supplement presented as a beverage or in a food, such as a spread?
» Bioavailability issues. How absorbable are the nutrients from the preparation? How utilizable are they after uptake?
» Miscellaneous issues. Does the preparation contain fat? Does it have animal-based additives that might be taboo for consumption by members of certain religious groups?

The questions identified as requiring research within this area are:

» What are the effects, if any, of nutrient-nutrient interactions on safety of the formulation?
» What are the effects, if any, of nutrient-nutrient interactions on efficacy of the supplement?
» What are the effects, if any, of nutrient-food interactions on safety of the formulation?
» What are the effects, if any, of nutrient-food interactions on efficacy of the supplement?

The justification for addressing these questions derives from the well-known interactions such as those between zinc and iron, calcium and iron, calcium and zinc, food phytates and metals, and food fats and lipid-soluble nutrients. The efficiency of nutrient uptake may determine the outcome of supplementation for improved nutrition and adversely excess exposure. Additional comments included the notation that some, but not all, micronutrients have bioavailability issues. Some are absorbed with a fixed efficiency by the intestine without any factors known to enhance or inhibit uptake.

Target groups for intervention

The questions identified as requiring research within this area are:

- What are the appropriate target groups for interventions?
- How long during the life span should different interventions be sustained?

The justification for these recommendations can be summed up in terms of the existence of vulnerable groups with lower possibilities of meeting their RDAs through diet and having micronutrient-deficiency burdens. More research is needed to focus appropriately on subgroups within age-group categories that might have different needs. For instance, a formulation for the average toddler may not be sufficient for those who are of low birthweight. Formulations for pregnancy may not meet the needs for adolescent pregnancies.

Additional comments led to a discussion of whether interventions are justified on the basis of a human right to an adequate nutrient intake or are based only on demonstrable capacity to reverse existing micronutrient deficiencies. With respect to targeting, would the recipients be only the poor and vulnerable subpopulations within a society, or all members of a society? If any safety issues concerning excess exposure to one or another micronutrient were detected for a disadvantaged and underprivileged subpopulation, such concerns would surely be magnified for the more affluent members of the same societies.

Assessment of background status

The following question was identified as requiring research within this area:

- What are the pre-existing rates of inadequacy (deficiency) or adequacy in the potentially targeted populations?

The justification for these recommendations, which basically call for a survey of the populations of interest, is the fact that the need to motivate policy authorities to action requires showing them the evidence for the problem and its nature. However, it is impossible to assess the population nutriture for certain micronutrients. Moreover, if the model of a single-RDA dosage is under consideration, certain nutrient deficiencies (e.g., iron, zinc, and vitamin A) may not be efficiently or effectively addressed by supplementation at this level.

Assessment of biological impact issues

The following question was identified as requiring research within this area:

- What are the effects of multiple-micronutrient modules on functional outcomes for young children (growth, development, and disease resistance)?

The justification for these recommendations rests in the debate between evidence from “static” versus “functional” indicators of nutritional status. Sometimes, for policy justification, deficits in functions such as growth, development, or disease resistance are more motivating than evidence such as low biochemical concentrations. For safety, as well, evidence of dysfunction may be more interpretable and compelling than laboratory indices.

Functional outcomes with multinutrient interventions cannot be attributed to any specific nutrient. The nutrients are offered as an integrated package, and the results must be so interpreted. Given the low dose of each nutrient in the intervention, the question arose as to the basis for justifying the program by being able to show increased growth, better development, or higher resistance to infection. On the safety side, do we wait for a “functional” indicator of an adverse effect, e.g., decreased growth, to appear? For safety, monitoring of more sensitive and earlier indicators of adverse effects arises. These could be indices of elevated storage reserves or of oxidative or inflammatory stress.

Behavioral and anthropological (social science) questions

The questions identified as requiring research within this social sciences-related area are:

- What are the constraints to daily, intermittent, or weekly dosing?
- What are the complementary food contexts for feeding micronutrient interventions?
- What are the customs and perceptions of the target population?
- What is the acceptability of various micronutrient supplementation formats?

The justification for these questions is the inherent a priori ignorance about acceptability issues of new practices before the practice has been introduced. The constraints to daily, intermittent, or weekly dosing will differ from country to country. Clearly, schoolchildren and factory and plantation workers are more readily reached. Compliance with any approach, including “foodlets,” will depend on local customs, culture, and perceptions.

Some dissenting and nonconsensus statements arose. One member felt that the efficacy of weekly dosing intervals as measured by some outcomes in the IRIS data may be too “weak” to justify this dosing interval for programmatic action. It was recognized that the dosing schedules could be "top down," i.e., dictated by public health authorities, or "bottom up," in which the behavioral possibilities are identified by the community and the dosage pattern is adapted to the culture. Both approaches have advocates.

Overall priority ranking

At the conclusion of deliberation, the group was polled as to which of the terms of the research agenda matrix in table 1 were to be considered to have the highest priority. Since members rated either one or two terms, a weighted rating of terms is provided in table 2.

TABLE 2. Global priority rating for the research agenda in future multi-micronutrient investigation

Item	Chosen priority
Efficacy studies	6
Safety research	3
Magnitude of deficiency	2
Behavioral research	2
Effectiveness research	1
Bioavailability studies	1

Conclusions

There are multiple micronutrient deficiencies in the disadvantaged populations of the world, and a multinutrient solution or solutions are needed. To achieve this goal, the policy and program interventions must be supported by research. The working group, addressing the perceived gaps in our epidemiological, behavioral, and technical understanding and capacity for devising and implementing programs, has formulated a series of research questions. The highest areas for inquiry are efficacy and safety of multiple micronutrient supplements. It is hoped that resources can be mobilized to address the agenda, and that addressing the outlined research will truly facilitate the programmatic solutions.

Development and sensory acceptability of crackers made from the big-eye fish (Brachydeuterus auritus)

Modupe Abimbola King

Key words: Fish crackers, cassava starch, sensory evaluation

Abstract

*The big-eye (*Brachydeuterus auritus*), which is present in a large biomass in the Gulf of Guinea, is generally considered an underutilized fish species. In an attempt to add value, it was used to complement cassava starch (*Manihot esculenta *Crantz) to produce fish crackers. Three levels of fish (40%, 50%, and 60%) and three levels of starch (60%, 50%, and 40%) were used in the formulations. Proximate analyses and sensory evaluations were carried out. The protein, fat, and ash contents increased with an increase in the proportion of fish. The sensory evaluation tests showed that the most acceptable formulations for the crackers were obtained using 50% fish/50% starch and 40% fish/60% starch combinations. The linear expansion of the fried crackers increased with the increased proportion of fish. Production of fish crackers, apart from its appeal for increasing protein intake, has the potential to support a small regional snack factory in a developing economy.*

Introduction

The big-eye (*Brachydeuterus auritus*) is an important component of the complex species mix of the Gulf of Guinea. There are an estimated 50,0000 tons of this species in the subtropical ECAF spell out [1, 2]. It is generally considered an underutilized fish species [3]. Its domestic consumption is limited by its small size, with a reported maximum length of about 25 cm at maturity, and by the absence of a defined use.

The big-eye is abundant and low in cost, which are criteria desirable for the development of value-added products. One of the ways to add value is to use it to complement low-protein staples, such as cassava (*Manihot esculenta* Crantz), in fish crackers, since cassava starch has been known to produce crackers with excellent expansion properties [4]. Cassava, with less than 3% protein, does not provide adequate protein for human requirements, even when ingestion exceeds calorie requirements [5]. In contrast, the amino acid content of fish and its essential amino acid balance are appropriate for human consumption. Therefore in a formulated mixture, an improved balance of amino acids may be obtained.

Crackers (*keropok*) are popular snack foods in Malaysia and other Asian countries [6]. They are produced by gelatinization of starchy dough that is shaped into different forms before drying. Apart from the two essential components of starch and water, other ingredients, such as fish or other types of seafood, are usually added to produce different types of crackers [7]. Fish crackers made from cassava starch and big-eye, properly formulated with high nutritional and sensory qualities, have the potential of being a source of essential nutrients, especially for children and teenagers. In addition, a snack with high nutritional and sensory qualities, properly formulated and adequately packaged, may be an appealing product for small regional snack factories in developing countries [8].

There is, however, a need to test the suitability of big-eye and cassava starch for the production of fish crackers in terms of taste and other sensory attributes. This is because taste will continue to be a driving force in the acceptance of a new food product in the competitive marketplace of the food-processing industry [9].

The objective of this study was to test the acceptability of fish crackers prepared from big-eye fish and cassava starch using different formulations.

The author is affiliated with the Nigerian Institute for Oceanography and Marine Research (NIOMR) in Victoria Island, Lagos, Nigeria.

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

Materials and methods

Preparation of fish crackers

Frozen big-eye fish was obtained from a fishing company, Obelawo Facha, in Lagos. The flesh was separated from the bones by a mechanical deboner after knobbing, gutting, and cleaning. The fish mince, cassava starch, and fish crackers were prepared as shown in figure 1. The mince obtained was mixed with dried cassava starch at a fish-to-starch ratio of 40:60 (A), 50:50 (B), and 60:40 (C); 1% sugar, 1.5% salt, monosodium glutamate, and 20% to 30% water were added to the mixture. The ingredients were mixed mechanically until a smooth paste was obtained. The paste was molded into a sausage-like shape using molds made of cylindrical metal rods, about 4 to 6 cm in diameter and 20 to 25 cm deep. The sausage was then encased in polyethylene casings before steaming for 90 minutes. The steamed pastes were cooled in cold water to minimize shrinkage and chilled overnight in a refrigerator at 1° to 5°C. The chilled pastes were cut into slices about 2 to 3 mm thick and dried in an oven at 50°C for 10 to 12 hours until a moisture content of 10% ± 2% was obtained. The dried slices were deep fried in vegetable oil at 175°C for 1 minute. Frying made the slices expand and increase in size to obtain a low-density porous product known as fish crackers.

Measurement of linear expansion

Linear expansion was determined by measuring five lines drawn across each chip before and after frying [10]. The lengths of individual lines were measured with a thread and a measuring tape. The measurement was replicated 10 times. The linear expansion of the crackers is a measure of textural quality and was calculated from the equation:

$$(LE) = 100\ (L_f - L_o)\ L_o^{-1}$$

where L_o and L_f are the lengths in centimeters of the lines before and after frying, respectively [7].

Sensory evaluation and proximate analyses

A laboratory panel consisting of 10 members evaluated the color, texture (assessed as crispness), flavor, and overall acceptability of the fried samples. The panelists evaluated the samples independently, and the tests were duplicated. The panelists received coded samples of crackers prepared using the three different formulations and were asked to rank them according to intensity of color, texture, taste, and overall acceptability [11]. The ranks were converted to scores, which were then subjected to analysis of variance. Treatment means were further subjected to Tukey's test to evaluate the difference between the samples [11].

This initial study was followed by a large-scale market testing during exhibitions in four cities: Abuja, Lagos, Kaduna, and Minna.

Crude protein (N × 6.25) was determined by the micro-Kjeldahl method [12], and total lipids were

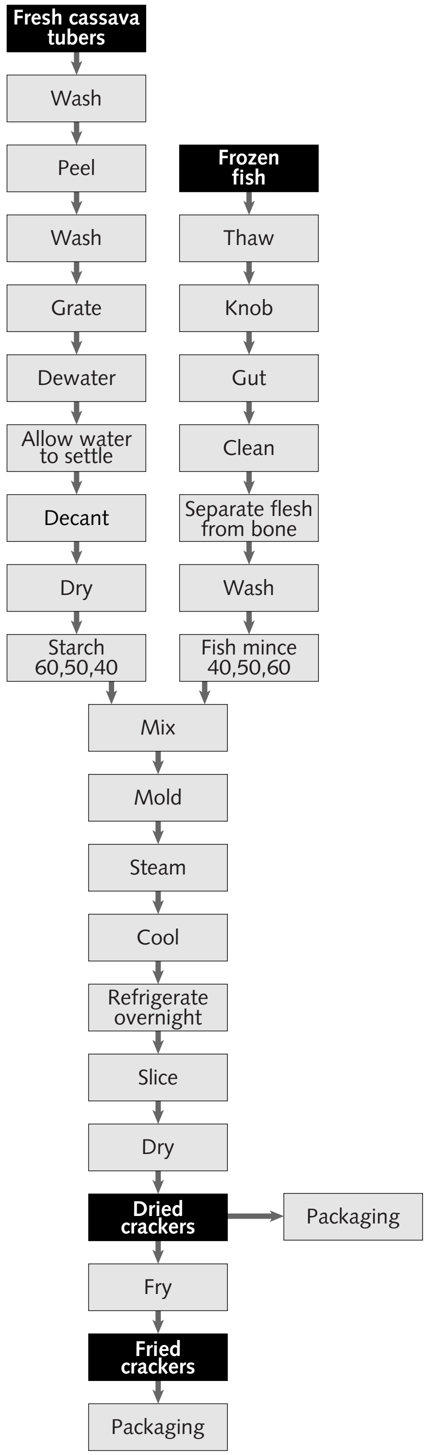

FIG. 1. Flow diagram for preparing cassav-fish crackers

estimated by petroleum ether extraction. Total ash was determined by ashing for 12 hours at 550°C, and the moisture content was determined by weight differences of samples dried in a vacuum oven at 60°C until a constant weight was obtained.

The linear expansion, sensory attributes, and nutrient contents of the three different fish and starch combinations were compared.

The proximate analyses of the different formulations are shown in tables 1 and 2. As expected, the protein content of dried and fried crackers increased with an increase in the proportion of fish. The crude protein content of the dried samples was comparable to that obtained from crackers prepared by using *Clupea leiogaster* and tapioca-sago flours [6]. The protein content of the fried crackers was lower than that of the dried crackers because of absorption of oil during frying (table 2).

Crispness, the most important sensory attribute of crackers, is directly related to linear expansion. A linear expansion greater than 77% is required for an acceptable level of crispness [13]. The linear expansion ratings of the fried crackers increased with an increase in the amount of fish (table 2). In previous work on expansion using soybean/cassava [5], wheat flour/wheat starch [14], and tapioca/rice starch [15], an increase in the protein content of the blends caused a decrease in the linear expansion of the extrudates. However, in a study of soy, wheat, milk, and egg proteins, milk protein tended to increase expansion volume, whereas the other proteins decreased expansion [16]. This was related to the viscoelastic nature and the cross-linking ability of different proteins. As the degree of cross-linking increases, the amount of expansion during frying decreases [16]. The increase in linear expansion with an increased proportion of fish may be associated with myofibrillar protein (particularly myosin) present in minced fish, which has the ability to form a gel.

The taste panelists found no significant difference in the flavor and crispness of the different formulations (table 3). However, they rated the color and overall acceptability of samples A (40% fish/60% starch) and B (50% fish/50% starch) significantly ($p < .05$) better than that of sample C (60% fish/40% starch). The preferred samples had brighter colors.

Conclusions

Acceptable fish crackers were produced from big-eye fish and cassava starch. Laboratory sensory scores and preliminary large-scale sensory evaluation trials were favorable and encouraging. Processing these low-value fish species into value-added products by using simple

TABLE 1. Percentage chemical composition of dried crackers before frying (means of two replicates)

Treatment	Protein	Fat	Ash	Moisture
A: 40% fish/60% starch	10.0	0.5	3.8	11.7
B: 50% fish/50% starch	14.5	0.8	4.2	11.9
C: 60% fish/40% starch	19.3	1.9	4.8	11.7

TABLE 2. Percentage chemical composition and linear expansion of cracker after frying (means of two replicates)

Treatment	Protein	Fat	Ash	Moisture	Linear expansion
A: 40% fish/60% starch	8.3	19.8	1.5	3.0	63.4
B: 50% fish/50% starch	12.7	20.0	2.0	3.8	79.2
C: 60% fish/40% starch	16.9	21.4	3.0	4.1	95.4

TABLE 3. Mean values for sensory attributes of fish crackers prepared from big-eye fish and cassava starch[a]

Treatment	Color	Crispness	Flavor	Overall acceptability
A: 40% fish/60% starch	±0.38a	±4.25	–0.85	±0.19a
B: 50% fish/50% starch	±0.19a	–0.85	+4.25	±0.38a
C: 60% fish/40% starch)	–0.57b	–3.40	–3.40	–0.57b
		NS	NS	

a. Means followed by different letters are significantly different at $p \leq .05$ by Tukey's test. NS, Not significant.

technology would not only increase their economic value but also encourage the exploitation of these underutilized resources, thus contributing to poverty alleviation and income generation in developing countries such as Nigeria. Production of fish crackers, apart from increasing protein intake, has the potential to support a small regional factory in a developing economy.

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Nutritional status of rural women in relation to their participation in mixed farming in the Tafresh area of Iran

Hossein Shabanali Fami, V. Veerabhadraiah, and Kamal G. Nath

Key words: mixed farming, energy intake, energy expenditure, energy balance

Abstract

This study was conducted in the Tafresh area of Iran to assess the dietary patterns, time allocation, and nutritional status of rural women in relation to their participation in mixed farming activities. We selected 75 women from 40 villages by applying a stratified random-sampling technique. Cereals and grains were the major source of energy intake. According to the recommended dietary allowance (RDA) tables of India, the United States, the United Kingdom, and the Food and Agriculture Organization (FAO), the respondents seemed to have no micronutrient and energy deficiencies during the spring season. They spent most of their time and energy on household, animal husbandry, and crop farming activities. According to measurements of body mass index (BMI), the respondents were well nourished. However, despite the high level of BMI, analysis suggested a negative energy balance. Nevertheless, analysis indicated that rural women with negative energy balance spent more time and energy in mixed farming and had a higher level of participation in related activities. Hence, it is evident from the results that the physical contribution of rural women in mixed farming activities has a detrimental effect on their nutritional status, at least during some parts of the year (e.g., spring or summer). Therefore, there is a need to adjust nutritional interventions to improve the sustainability of their food intake and to develop appropriate technologies in mixed farming to alleviate their work burdens.

Hossein Shabanali Fami is an assistant professor in the Department of Agricultural Extension and Education, University of Tehran, in Karaj, Iran. V. Veerabhadraiah is a professor and Director of Extension in the University of Agricultural Sciences in Bangalore, India. Kamal G. Nath is an associate professor in the Department of Rural Home Sciences in the University of Agricultural Sciences in Bangalore.

Introduction

Livestock makes a major contribution to rural development in developing countries [1]. Among different livestock production systems, mixed farming or the crop–livestock integrated production system is probably the most benign from an environmental perspective. In addition, mixed farming is the largest category of livestock production in the world [2]. Hence, a thorough understanding of this system can help to identify constraints and opportunities affecting the productivity of human resources, the sustainability of the system, and the nutritional status of resource-poor farmers, particularly disadvantaged populations such as rural women.

Because rural women play a crucial role in mixed farming throughout the world, special attention should be paid to their particular needs, roles, and problems. Therefore, this study, which examined the nutritional status of rural women in relation to their participation in mixed farming, can be useful for the design, development, and promotion of sustainable livestock production systems in Iran or other places with similar conditions. This investigation can also provide extensionists, researchers, agricultural planners, and policy makers with information that is essential for the establishment or accomplishment of any development intervention. It is because women's empowerment in agriculture or mixed farming as a part of human-resource development programs is influenced by many factors, including educational level, health conditions, nutritional status, access to credit, and appropriate technology.

Although these factors are interrelated, nutritional status seems to play a major role in the productivity of women in mixed farming. By contrast, nutritional deficiencies have negative effects on women's capacity for physical work. Some studies have shown that a woman's physical capacity for work is a major determinant of her own and her family's nutritional well-being [3]. Because of the importance of food availability and food habits and their impact on the productivity of women

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in mixed farming, the present study was conducted to study the nutritional status of rural women, their daily time allocation and energy expenditure patterns, and the relationship between their nutritional status and their participation in mixed farming.

Methods

The study was conducted in the Tafresh area of Iran, where mixed farming is the main occupation in rural areas. Mixed farming is defined as a system of farming in which both crop and livestock farming are combined for the purpose of meeting family requirements and earning a profit from both enterprises. The data were collected during the spring season. In order to enhance the representativeness of the sample, data were gathered from two districts, Markazi and Farahan. Seventy-five women were selected from 40 villages by a stratified random-sampling technique.

Nutritional status

In this study, nutritional status refers to the dietary patterns, energy expenditure, and energy balance of the respondents. Time spent in different activities was also studied as a prerequisite for assessing energy expenditure.

Dietary pattern

For this study, dietary intake is defined as the total amount of different foods consumed by women throughout the day, including beverages. Dashman et al. [4] have characterized methods of dietary assessment as retrospective and prospective. The major retrospective method is the 24-hour recall. The subject is asked to recall all foods and beverages consumed in the previous 24 hours. Thimmayamma [5] and Nieman et al. [6] believe that this is a more practical and useful method of assessing the dietary intake of individuals in a family than other methods. The recall method also gives fairly reliable data on the current food consumption of a large group. By this method, dietary intake data for the previous 24 hours were collected from the women with the help of a set of four standardized containers. The individual intakes were calculated for each subject by the method of Thimmayamma [5]. The energy and nutrient intake of each subject were then calculated by using the food composition table of Iran [7].

Time utilization (allocation) pattern

Time allocation is defined as the total time (in minutes) spent in different types of activities during the day. The allocation of time to different types of activities was measured by a schedule prepared for this purpose as a prerequisite to assessing energy expenditure.

Energy expenditure

Energy expenditure is operationally defined as the total amount of energy expended in various forms of activities and at rest. Physical activity is the most important component affecting energy output. The energy required for different activities varies with a number of factors. However, after discussion with experts, a review of the literature, and interviews with the women in the study area, and also keeping in mind the time of year (seasonal effect), a list of 52 activities was included in the schedule prepared to assess the energy expenditure of the women.

Throughout this survey, the respondents were asked to determine the time spent on each classified activity during the previous 24 hours. In order to estimate the total calories spent on each activity, the standard tables of energy cost in different activities (min/kcal) given by the Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/UNU) [8] were used. First, the detailed time spent on different types of activities by the respondents the previous day was recorded based on their recall. Then, the energy cost per minute for each activity was obtained from the standard tables and multiplied by the time spent on the activity to calculate the daily energy expenditure for that activity. The total energy expenditure was then computed by summing the daily energy expenditure for all the activities.

Energy balance

For an individual to be healthy and in good physical condition over a period of time, his or her energy input must be equal to the energy output. In this study, energy balance is operationally defined as the equilibrium between energy intake and energy expenditure. According to the value obtained for energy balance, the respondents were classified into two groups, those with positive energy balance and those with negative energy balance.

Body mass index (BMI)

The body mass index or Quetelet’s index (the weight in kilograms divided by the square of the height in meters) of the respondents was calculated. The classification suggested by James et al. [9] and Rao and Vijayaraghavan [10] was used for the study. Based on this classification, a BMI of less than 20 indicates chronic energy deficiency or underweight, a BMI between 20 and 25 is normal, and a BMI over 25 indicates overweight or obesity. The body weight and height of the subjects was measured by a single investigator using the same measurement tools and methods. The respondents were weighed in their normal clothing, and their heights were measured by using a PVC-coated fiberglass tape.

Participation of rural women in mixed farming

To measure the extent of participation of the women in mixed farming, an index was developed in which items related to two main components of mixed farming (crop farming and animal husbandry) were included. Two levels of participation (work and decision-making participation) were determined.

Results and discussion

Mean food and nutrient intake of the subjects

The data presented in table 1 show the average food and nutrient intake of the women obtained from different food groups. Energy intake came from cereals and grains (46.7%), pulses and legumes (12.8%), meat and meat products (11.6%), milk and dairy products (10.0%), fats and oils (7.7%), sugars (7.6%), vegetables and fruits group (2.8%), and the miscellaneous group (0.8%).

Cereals and grains also contributed other nutrients, such as protein (41.8%), fiber (47.9%), and iron (60.5%). Meat and meat products provided the most fat (40.3%), followed by fats and oils (29.5%) and milk and dairy products (21.5%). Milk and dairy products were the major sources of calcium (56.9%), followed by cereals and grains (22%) and pulses and legumes (14%). Retinol was mainly obtained from vegetables and fruits (94%).

Food habits are profoundly influenced by cultural, personal, situational, and economic factors. The data showed that cereals and animal products were the main staples. This is substantially attributable to the dominance of mixed farming as well as the high percentage of the population consuming self-produced food in the area of study. In addition, the effect of seasonal factors is very important. For example, nutrient intake is improved by a marked increase in the consumption of vegetables, which contain a large amount of retinol equivalent, iron, and calcium. More vegetables are consumed during the spring, when rural women collect many types of edible wild vegetables growing in the fields or the surrounding hills and pastures. These findings are in agreement with those of others [11–14].

TABLE 1. Mean food and nutrient intake of the subjects (*n*=75)

	Food group								
Nutrient	Cereals and grains	Pulses and legumes	Milk and dairy products	Meat and meat products	Vegetables and fruits	Fats and oils	Sugars	Miscellaneous	Total
Energy									
kcal	1,215	333	262	302	72	201	197	20	2,602
%	46.7	12.8	10.0	11.6	2.8	7.7	7.6	1.0	100
Protein									
g	35.6	19.4	19.1	7.2	3.4	0	0	0.4	85.1
%	41.8	22.8	22.5	8.5	3.9	0	0	0.5	100
Fiber									
g	4.2	3.5	0	0	1.1	0	0	0	8.8
%	48.00	39.0	0	0	13.0	0	0	0	100
Fat									
g	3.0	3.2	12.3	30.4	0.4	22.2	0	0.1	71.6
%	4.2	4.5	21.7	42.5	0.5	31.0	0	0.1	100
Iron									
mg	18.5	5.0	1.9	2	2.9	0	0.2	0.2	30.7
%	60.5	16.4	6.1	6.5	9.3	0	0.6	0.6	100
Calcium									
mg	163.4	104.3	422.8	5.3	44.8	0	0	2.5	743.1
%	22.0	14.0	57.0	0.7	6.0	0	0	0.3	100
Retinol									
µg	0	0	16.1	8.5	1,191.2	22.9	0	29.0	1,267.8
%	0	0	1.3	0.7	93.9	1.8	0	2.3	100

Comparison of nutrient intake of the subjects with the recommended dietary allowances of other countries and their meal consumption pattern

The contribution of different meals in providing some basic nutrients and also the recommended dietary allowance (RDAs) of India, the United States, and the United Kingdom, as compared with the subjects' intake, are presented in table 2. The respondents followed four meal patterns: breakfast, lunch, tea and snacks at mid-day, and dinner. The major proportions of energy, protein, fiber, fat, and iron were provided by lunch, followed by dinner, breakfast, and mid-day tea and snacks. Breakfast contributed more calcium than the other meals, followed by lunch, dinner, and mid-day tea and snacks. Dinner contributed more retinol than the other meals, followed by lunch, mid-day tea and snacks, and breakfast.

The nutrient intakes of the women were also compared with the RDAs for India [15], the United States [16], and the United Kingdom [6]. In all cases, the amounts of nutrients and energy consumed by the subjects were higher than those recommended in the comparison countries. No RDAs have been established for Iran. The total average energy and nutrient intakes of the women were found to be 2,602 kcal, 85 g of protein, 8.8 g of fiber, 75 g of fat, 31 mg of iron, 731 mg of calcium, and 1,268 µg of retinol. According to the FAO/WHO/UNU recommendations [8], a farm woman with an average body weight of 60 kg needs about 2,820 kcal per day. Since the average energy intake of the subjects was 2,602 kcal, they were consuming about 200 kcal less than the FAO/WHO/UNU recommendations. This variation is not surprising, because the energy intake of the respondents changes in different seasons and areas. It would probably be different in the summer (peak season), fall, and winter.

According to the classification of Sudeh et al. [17], when the energy intake is above the RDA, it can be considered adequate. According to this criterion, the respondents are well-nourished. However, comparison of mean intakes with the RDAs of other countries is not sufficient, and RDA tables should be developed for the Iranian people. These findings are in agreement with the findings of others [18].

Daily time allocation and energy expenditure of rural women in different types of activities during the spring season

Individual energy expenditure depends on the amount of time spent on various activities and the body's basic energy needs for maintaining life processes. Table 3 indicates the time allocation and energy expenditure of the women in different types of activities during the spring season. Out of each 24 hours, the respondents spent 1,113 minutes (about 19 hours) in household activities, rest, and sleep, followed by 259 minutes (about 4 hours) in animal husbandry and 68 minutes (about 1 hour) in crop farming activities. Similarly, they spent more energy in household activities (1,492 kcal), followed by animal husbandry (741 kcal), and crop farming activities (179 kcal).

The women spent more time and energy in animal husbandry than in crop farming. Table 4 shows that 22.7% of the total time and 38.1% of the total energy were spent in mixed farming activities during the spring season. The burden and workload of crop farming and animal husbandry activities on women are less during the spring than during the peak season or the summer.

TABLE 2. Nutrients consumed by subjects in different meals compared with the RDA of other countries and FAO

Nutrient	Unit (%)	Meals: Breakfast	Lunch	Tea and snacks	Dinner	Total	RDA: India	USA	UK	FAO
Energy	kcal	542	943	233	883	2,602	2,225	2,000	2,500	2,820
	%	20.8	36.3	8.9	34.0	100	—	—	—	—
Protein	g	15.2	35.9	7.2	26.9	85.2	50	44	62	—
	%	17.8	42.1	8.5	31.5	100	—	—	—	—
Fiber	g	1.4	3.6	0.8	3.0	8.8	—	—	—	—
	%	15.4	41	9.0	34.1	100	—	—	—	—
Fat	g	9.9	30.8	7.1	27.7	75.5	20	—	—	—
	%	13.1	40.8	9.4	36.7	100	—	—	—	—
Iron	mg	6.9	10.3	3.5	9.9	30.6	30	18	12	—
	%	22.6	33.6	11.3	32.4	100	—	—	—	—
Calcium	mg	250.8	223.0	92.0	177.2	743.0	400	800	500	—
	%	33.8	30.0	12.4	23.8	100	—	—	—	—
Retinol	µg	41.0	528.0	54.0	645.0	1,268.0	600	800	750	—
	%	3.2	41.6	4.3	50.9	100	—	—	—	—

Therefore, the energy expenditure and time spent in mixed farming activities are expected to be greater during the peak season. Although animal husbandry is a relatively constant activity throughout the year, crop farming is influenced by seasonal factors. For example, women have to spend the most time and energy in crop farming during the summer and the least during the winter. Accordingly, these figures are indications of the time allocation and energy expenditure pattern during the spring, although interseasonal variations may still exist. These findings are in conformity with those of others [19–23].

TABLE 3. Daily time allocation and energy expenditure of rural women in different types of activities in the spring season

Household			Crop farming			Animal husbandry		
Activities	Time (min/day)	Energy (kcal/day)	Activities	Time (min/day)	Energy (kcal/day	Activities	Time (min/day)	Energy (kcal/day)
Cooking	87.8	153.7	Seed treatment	0	0	Cutting fresh grass with a machete	23.7	83.4
Fetching water	4.4	21.5	Carrying load from house to the farm on shoulder or head	7.6	38.3	Milking by hand	32.4	48.5
Washing dishes	55.2	92.7	Removing and collecting weeds	5.2	13.5	Feeding animals	30.5	83.3
Washing clothes	23.5	63.2	Hand weeding	9	23.3	Watering animals	26.6	107.5
Collecting fire-wood	5.6	22.4	Irrigation	15.3	24.7	Grazing animals in farm or pasture	30.4	129.2
Child care	25.6	56.8	Thinning	0	0	Cleaning cattle shed	12.7	39.6
Personal care	18.3	35.5	Harvesting field crops	0	0	Artificial fostering of calves/lambs	0.2	0.2
Recreation	30	45	Harvesting fodder	10	31	Chaffing fodder	11.6	58
Sleeping	567.6	567.6	Threshing	0	0	Shearing sheep/lamb	0.5	0.8
Bread-making (tortillas)	15.1	31.6	Winnowing and sieving	4.8	7.8	Collecting eggs	14.5	45.9
Shopping	10.7	29.2	Bagging	1.6	1.8	Feeding birds	16.3	18.7
Sweeping house (yard)	14.8	46.2	Collecting straw or stubble	3.2	11.4	Making dairy by-products (curd, cheese, etc.)	36.5	75.8
Eating	66.8	80.3	Picking fruits and vegetables	1.7	4.2	Wool processing	0	0
Breastfeeding	1.0	1.14	Harvesting root crops	0	0	Carrying animal husbandry products	8	32.3
Sewing clothes	1.7	2.4	Planting vegetable and root crops	0	0	Repairing or constructing animal shed	0.2	0.7
Carpet weaving	4.4	15.4	Drying fruits and vegetables	6.2	15	Selling animal products	14.9	17.1
Cleaning house	10.5	23.1	Processing agricultural produce	1.7	5.7			
Resting or sleeping	170	204	Selling agricultural produce	1.7	2			
Total	1,113	1,491.8		68	178.7		259	741

TABLE 4. Comparison between energy expenditure and time allocation of rural women (n=75) for different types of activities during the spring season

	Energy (kcal/day)			Time (min/day)		
Activity	Mean	SD	%	Mean	SD	%
Household	1,492	326	61.9	1,113	184	77.3
Mixed farming	920	596	38.1	327	184	22.7
Crop farming	179	262	7.4	68	105	4.7
Animal husbandry	741	457	30.7	259	119	18
Total	2,412		100	1,440		100

Selected anthropometric measurements of rural women

Some of the most commonly used anthropometric measurements in routine surveys are body weight, crown-heel length or standing height, and BMI [10]. These were applied in the present study as determinants of the subject's nutritional status. BMI provides a reasonable indication of nutritional status. It can serve as an indicator of health risk. Leslie et al. [3] found that women with BMI in the normal range are able to spend more time in work-related activities, including home production.

The data presented in table 5 show some selected anthropometric measurements of the women. The mean body weight and standing height were about 61 kg and 155 cm, respectively. Their body weight was about 9% higher than that of a reference woman [8]. The mean BMI was about 25. The great majority of the respondents (more than 90%) had a BMI above 20, indicating that they had a sound nutritional status (table 6), although their energy balance may change during the different seasons. According to Rao and Vijayavaghavan [10], BMI correlates with fatness. The fat content of 100 g of sheep meat is about 54 g as compared with 7 g for the same amount of cattle meat [7]. Therefore, the higher consumption of sheep meat in the study area might be another reason for the prevalence of overweight.

For example, the women may have negative energy balance during the spring because rural boys and girls attend school during the spring, fall, and winter, which increases the responsibility of mothers to perform their home or farm tasks alone. Further, there is a lack of sufficient income during the spring as compared with the summer and fall, when the people can sell their agricultural products and get more cash. This may require the women to undertake additional off-farm activities in the spring season.

TABLE 5. Selected anthropometric measurements of rural women (*n*=75)

Measurement	Mean	SD
Body weight (kg)	60.95	8.9
Standing height (cm)	154.71	7.9
BMI	25.61	4.3

TABLE 6. BMI of rural women

Range	Description	*N*	%	χ^2
<20	Energy deficient	3	4	5.34 NS
20–25	Normal	36	48	
>25	Overweight	36	48	

Women's workload in the study area diminished during the fall and winter seasons. During this period, which lasts about six months, their nutritional status improved. Since the data were collected in the spring just after that period of light workload, the study recorded a greater number of overweight women. Accordingly, if the data were collected at the end of the peak season, the negative balance would be higher. This result points to the increased workload in summer, which may have a deleterious effect on the energy balance of the study women. Further studies are needed to compare the impact of seasonality on the nutritional status of rural women in Iran.

Relation between energy expenditure and time spent by rural women in mixed farming, as well as the relation of energy balance with other nutritional variables

A correlation coefficient was calculated to determine the relation between energy expenditure and time spent by the women on mixed farming, as well as the relation of energy balance with other nutritional variables. There was a significant negative relationship between energy balance and the amount of energy and time spent on mixed farming (table 7). This is strong evidence for an effect of the participation of rural women in mixed farming on the deterioration of their nutritional status. Accordingly, the majority of rural women

TABLE 7. Relationship of energy expenditure on mixed farming, time spent in mixed farming, and energy balance of rural women with other nutritional variables (correlation coefficient)

Nutritional variables	Energy expenditure in mixed farming	Time spent in mixed farming	Energy balance
Total energy expenditure	0.87**	0.79**	–0.39**
Total energy intake	0.02	0.05	0.89**
Energy expenditure in crop farming	0.70**	0.76**	–0.30**
Energy expenditure in animal husbandry	0.91**	0.83**	–0.34**
Energy expenditure in household activities	–0.80**	–0.83**	0.25*
Time spent in crop farming	0.68**	0.79**	–0.26*
Time spent in animal husbandry	0.88**	0.85**	–0.26*
Time spent in household activities	–0.96**	–1.00**	0.32**
Energy balance	–0.39**	–0.32**	1.00

* Significant at 5%.
** Significant at 1%.

with negative energy balance would have higher levels of participation in mixed farming.

This relationship is largely due to the lack of appropriate technologies available to rural women or to their hard working conditions, which make mixed farming drudgery for them. Similarly, examination of the relationship of energy balance with other variables indicated that those women who were engaged in more household activities had a higher energy balance, which is an indication of better nutritional status. Therefore, the nutritional status of rural women participating in mixed farming should be improved through developmental strategies such as nutritional education, food supplementation, and introduction of appropriate technologies. According to McGuire and Popkin [24], four classes of interventions are likely to reduce the constraints of women and improve their nutritional situation: increasing women's income and their control of income and productive resources, reducing their child-care burden, increasing their productivity in household production, and improving their own health and nutrition directly [25]. In addition to these interventions, the results of this study indicate that reducing the work burden of mixed farming through appropriate technology would help in increasing the nutritional status of women in low-income families.

Category-wise comparison of rural women on selected variables based on their energy balance

The *t*-test was used to compare the two groups of women with positive and negative energy balance (table 8). The two groups were significantly different in total energy expenditure, energy expenditure in crop farming, energy expenditure in animal husbandry, energy expenditure in mixed farming, time spent in animal husbandry, time spent in mixed farming, and overall participation in animal husbandry and mixed farming. The mean values of these measurements were higher in the group with negative energy balance than in the group with positive energy balance. The mean values of total energy intake and time spent in household activities were higher in women with positive energy balance than in those with negative energy balance.

It is evident that women with positive energy balance spent more time and energy in household activities, and those with negative energy balance spent more time and energy in animal husbandry and mixed farming. Those with negative energy balance also had higher levels of work and overall participation in animal husbandry and mixed farming. In other words, time spent, energy expenditure, and work participation in mixed farming and animal husbandry had considerable effects

TABLE 8. Comparison of selected characteristics of rural women based on their energy balance

Characteristic	Negative energy balance (n=31)		Positive energy balance (n=44)		t
	Mean	SD	Mean	SD	
Total energy intake (kcal)	2,106.00	376.6	2,951.00	791.4	6.16**
Total energy expenditure (kcal)	2,602.54	418.9	2,276.81	306.1	3.69**
Energy expenditure in crop farming (kcal)	259.59	303.4	121.70	213.5	2.18*
Energy expenditure in animal husbandry (kcal)	914.85	501.8	618.46	383.8	2.88**
Energy expenditure in mixed farming (kcal)	1,174.44	687.2	740.16	457.5	3.07**
Time spent in animal husbandry (min)	294.48	134.5	234.27	102.7	2.20*
Time spent in mixed farming (min)	389.97	212.1	282.45	148.8	2.58*
Time spent in household work (min)	1,050.03	212.1	1,157.55	148.8	2.43*
Work participation in animal husbandry (scores)	82.39	27.4	69.70	25.3	2.06*
Overall participation in animal husbandry (scores)	102.39	31.0	87.80	28.9	2.09*
Work participation in mixed farming (scores)	122.05	31.5	105.11	30.0	2.36*
Overall participation in mixed farming (scores)	153.95	42.1	132.45	36.5	2.35*

* Significant at 5%.
** Significant at 1%.

on the energy balance of the women, often shifting it to the negative side. These findings again confirm that mixed farming activities have a direct impact on the energy balance and thereby the nutritional status of rural women. Mixed farming could reduce the women's appetite by causing fatigue and could also reduce the time available for cooking and improving the nutritive value of the diet.

Conclusions

An analysis of dietary patterns indicated that cereals and grains were the major source of energy. According to the RDAs for India, the United States, the United Kingdom, and FAO, rural women in the Tafresh area of Iran seemed to have no micronutrient and energy deficiencies during the spring season. These women spent most of their time and energy in household, animal husbandry, and crop-farming activities. According to anthropometric measurements, the women were in sound nutritional status, while at the same time about 41% of them had a negative energy balance. This is because energy balance is a short-term indicator of nutritional status and is highly sensitive to daily energy intake and expenditure, whereas BMI is a long-term indicator showing the overall energy balance over years.

The results imply seasonal fluctuations in the quantity, quality, and type of women's diets, as well as variable participation by them in mixed farming activities throughout the year. In other words, the findings indicate that a woman with a good BMI may suffer from adverse effects of nutritional deficiencies in some period of the year due to greater physical activity. This is because women's contributions to mixed farming activities tend to be seasonal. However, further analysis demonstrated a significant negative relationship between energy and time spent by the women in mixed farming and their energy balance. Hence, it is evident from the results that the physical contribution of the women to mixed farming activities may adversely affect their nutritional status, at least during some parts of the year (e.g., spring or summer). Therefore, there is a need to take different nutritional interventions into account to improve the sustainability of food intake and to develop appropriate technologies in mixed farming to alleviate the work burdens of rural women.

More investigations on the relationship of the nutritional status of rural women to their physical participation, seasonality, and productivity in agriculture are recommended. Such research should examine the seasonal variability in both participation and the nutritional situation. The data must be collected at different times or seasons throughout an entire year. The findings will be useful for formulation of extension and nutrition programs.

Acknowledgments

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Group-based financial institutions for the rural poor in Bangladesh: An institutional- and household-level analysis

Manfred Zeller, Manohar Sharma, Akhter U. Ahmed, and Shahidur Rashid

In the last two decades, nongovernmental organizations (NGOs) in Bangladesh have provided millions of poor rural people with savings and credit services at low cost. With these services they have reduced poverty and may have improved food security and nutrition and achieved positive social change as well. These NGOs have different structures, modes of operations, and program goals, and are not legally registered as banks. Unlike the formal financial intermediaries, such as nationalized commercial banks, that lend on the basis of collateral—thus effectively excluding the poor—these microfinance institutions (MFIs) provide services to solidarity credit groups that poor community members have created. Small groups (5 to 10 members) form larger groups that then procure financial services. The NGOs thus make use of joint liability, peer selection, and experience with repeated financial transactions to overcome the informational constraints in formal financial markets. The MFIs harness some of the strengths of local organizations while also practicing sound business management.

Despite these programs and the increases in per capita income, widespread poverty and malnutrition continue to exist in Bangladesh. In 1997, the country was the eighteenth poorest in the world. The level of extreme poverty has hardly changed over time, and the incidence of poverty is greater now in rural areas, where 50% of the households are landless and employment opportunities are low. The natural disasters that Bangladesh experiences have caused even further setbacks in development.

Given the relative success of the MFIs and the pressing need for further poverty alleviation, Manfred Zeller, Manohar Sharma, Akhter U. Ahmed, and Shahidur Rashid undertook a study to examine four issues: (1) the determinants of the formation and outreach of MFIs; (2) the credit group formation process, the determinants of program eligibility, and the implications of eligibility requirements for the structure, conduct, and performance of the groups; (3) the financial sustainability of the lending institutions; and (4) the effects of participation on household resource allocation, income generation, food and nonfood consumption, and the social attitudes and capacities of their members.

In this report, the authors examine these issues by looking at the workings of three different institutions: the Bangladesh Rural Advancement Committee (BRAC), the Association for Social Advancement (ASA), and the Rangpur-Dinajpur Rural Services (RDRS). These NGOs represent, respectively, the three types of MFI in Bangladesh: those that have transformed their financial programs into banks; those that collect savings and make loans, but rely on the wholesale functions of rural banking networks; and those that do not handle funds, but instead facilitate the formation of members' groups and their linkange with banks.

Reaching the poor

Overall, the NGOs are highly successful in reaching those rural poor who farm less than one-half acre. They tend to place their offices within more developed rural areas with better access to infrastructure and banks and to avoid areas that are at high risk for flooding and other adverse events. Within the more developed areas, the NGOs provide poorer villages with their services and reach very poor people, mostly women, within the villages. But generally the NGOs have not assisted the ultra-poor of the many agricultural smallholders who farm more than one-half acre.

Services and sustainability

The selected NGOs exhibit important differences with respect to target groups and the type of services provided. Whereas ASA mainly finances off-farm enterprises for women, BRAC lends to women and men for both agricultural and nonagricultural activities. Households with less than one-half acre may join ASA or BRAC groups. The loans usually have a one-year maturity. Because borrowers must repay in weekly installments, many invest in businesses with a continu-

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ous cash return. During the 1990s, ASA focused on providing financial services while reducing its nonfinancial services, such as business management training. It has also begun serving households with more than one-half acre of land. BRAC, in contrast, assists in product marketing and operates as an integrated development organization, providing health services and medium-term investments for community improvement, among other activities.

RDRS promotes income generation within agriculture, animal husbandry, and fish farming. Because many of these enterprises require longer gestation periods, loans with different repayment plans are offered. RDRS also provides nonfinancial services and assists in product marketing. In 1989, RDRS changed the membership eligibility criterion from ownership of less than one acre to a maximum of 1.5 acres.

The MFIs, unlike the government banks that require heavy subsidies to remain solvent, are financially sustainable and among the most efficient credit organizations worldwide. The MFIs charge interest rates from 10% to 20% above the inflation rate, yet they have achieved repayment rates as high as 98%. The large Asian MFIs, including ASA and BRAC, have usually performed their operations without any subsidies. Smaller South Asian MFIs, however, spend about US$0.17 for each dollar loaned, of which US$0.05 must be covered by subsidies.

Impact on the poor

The targeted credit programs have had a positive impact on household welfare in a number of ways. The quantity and quality of food consumed, the health of household members, and children's education have improved. The survey of social attitudes and social capacity shows progress in social change, particularly in the areas of intrahousehold decision-making and women's coping capacity, physical mobility, and attitudes.

An econometric analysis reveals that access to credit has a significant and strong effect on generation of income and consumption of food and calories. Each Tk 100 (US$1.80) of credit access generates an additional Tk 37 of annual household income to ASA and BRAC members. This compares favorably with the cost of subsidizing this access. With a social cost of Tk 5 in the case of small and medium-sized MFIs, microfinance NGOs in Bangladesh are producing a net social benefit of Tk 32 for every Tk 100 they lend.

Policy implications

Group-based financial institutions can contribute greatly to poverty reduction in Bangladesh and offer a viable alternative to state and market failures in rural finance. Therefore, continuing public support for the expansion of these MFIs appears warranted. However, the current subsidy figures underestimate the actual costs of the programs. The study did not conduct a full cost-benefit analysis. The data do not include past subsidies for innovations and expansion phases or for unsuccessful MFIs. These costs would need to be considered in determining whether to invest in MFIs or other avenues for rural development. Nevertheless, the subsidy figures appear quite favorable compared with other capital transfers to the poor. Finally, to replicate the MFIs elsewhere, we must consider that their successful implementation necessarily involves adapting the organizational structure and practices to different socioeconomic and agroecological environments.

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In Memoriam

Miguel Layrisse, 1919–2002

Miguel Layrisse, one of Latin America's leading clinical research scientists, died in his native Caracas on February 22, 2002. He was still actively directing the Laboratory of Physiopathology, Venezuelan Institute of Scientific Investigation (IVIC), and was the senior author of a paper in press in the *Food and Nutrition Bulletin*. His studies of the factors inhibiting and promoting iron absorption were the first to explain the high global prevalence of iron deficiency despite its apparent adequacy in human diets. His persistence in identifying and evaluating various iron compounds for the fortification of cereal flours and foods contributed importantly to current global efforts to prevent iron deficiency. He was also the first to identify the mechanism of improvement of iron status by vitamin A and to demonstrate that severe iron deficiency interfered with the capacity to maintain body temperature. In the early 1960s, he provided the first quantitative estimates of blood loss from infections with *Trichura trichura* and the hookworms *Necator americanus* and *Anchylostoma duodenale.* Another original contribution was his discovery of the blood Diego factor.

Born in Caracas, he received his M.D. from the Central University of Venezuela (UCV) in 1943 and spent a year at the New England Medical Center in Boston before becoming Chief of Hematology at Carlos Bello Hospital (1948–1952) and Associate Professor of Pathology at UCV (1951–1952). After two years as Chief of Service, Hematopoietic Organs, at the Louis Razetti Institute, he became Associate Professor of Clinical Medicine at UCV in 1955–1962 and Professor in 1963. He served as Chief of the Department of Physiopathology of IVIC in 1961, a post he still held at the time of his death. From 1963 to 1968 he was Director of the WHO/PAHO Center for Nutritional Anemias in Latin America and the Caribbean and Chief of Medicine and the Laboratory of Hematology (IVIC). He then became Rector of the Central University of Venezuela for a four-year term. He served as Director of IVIC from 1980 to 1984 and again from 1992 to 1994. He was Director of the Laboratory of Physiopathology of IVIC from 1961 until his death. He was a leader in many other activities in Venezuela, including President of the Vargas Foundation and member of the Technical Commission for Medicine, CONICIT, the National Council for Scientific and Technical Investigation. Outside of Venezuela he served on the Research Advisory Committee of the Pan American Health Organization and many WHO Expert Committees. The United Nations University designated his unit in IVIC as a regional advisory center for Latin America.

He received many honors, including the Hernández Prize (1953), the National Research Prize (1956), the Creole Foundation Prize (1961), the Venezuelan Surgical Society Prize (1965), the Hernández Prize with Marcel Roche (1965), the CONICIT Prize in Medicine (1982), the National Science Prize (1983), the Order Andrés Bello Corbata (1968), the Order Francisco Mirando (1970), the Order Andrés Bello (1973), the Order Diego Lozada (1973), the Venezuelan Army Cross (1973), the Order Francisco de Miranda (1976), the Bernado Houssay Prize (1976), the Order of the Liberator–Comendador (1980), membership in the Venezuelan National Academy of Medicine (1982), the Order of the Liberator–Gran Oficial (1989), the Health Medal "Enrique Tejera" (1989), the National Health Cross (1993), the Health Medal Dr. Arnold Gabaldón–Ministry of Health (1994), the Order Vicente Emilio Sojo (1994), membership in the Legislative Assembly of the State of Miranda (1994), membership in the Third World Academy (1996), the Sol de Carabobo Prize (1997), and the Kellogg Prize (2000). A National Nutrition Prize "Miguel Layrisse" was established in his honor last year.

Miguel Layrisse was the first to use radioactive isotopes for the intrinsic labeling of food iron to determine iron absorption in humans in comparison with the absorption of labeled extrinsic iron. This enabled him to explain high anemia prevalence rates in developing country populations despite apparently adequate total iron intakes. His resulting classification of iron absorption as poor, fair, and good, depending on differences in dietary iron absorption in the diet associated with socioeconomic status, was adopted by the World Health

Organization and has been an important contribution to the epidemiology and prevention of iron deficiency. He was a pioneer in identifying inhibitors (phytates, tannins) and enhancers (ascorbic acid, vitamin A) of iron absorption. He demonstrated that vitamin A acted by enhancing the intestinal absorption of iron. He was the moving force in a national program in Venezuela for the enrichment of wheat and precooked maize flours that reduced the prevalence of anemia by 50% in two years and nearly doubled iron stores, despite deteriorating economic conditions.

His work is described in 270 scientific publications including important ones in the last two years. His pioneering leadership in the etiology, epidemiology, and prevention of iron deficiency is highly regarded in Latin America and throughout the world, as attested by his many honors and extensive involvement with international agencies, professional societies, and international congresses. He was a consistent contributor to the Latin American Nutrition Society (SLAN). He will be remembered globally as a pioneer in hematology, particularly for his studies of nutritional anemias in patients and populations. His contributions to nutrition meetings, the stimulation of his innovative research, and his friendship will be widely missed.

Nevin S. Scrimshaw

Books received

Childhood obesity: Prevention and treatment. Jana Parizkova and Andrew Hills. CRC Press, Boca Raton, Fla., USA, 2001 (ISBN 0-8493-8736-1) 422 pages, hardcover. US$69.95/£46.99.

Childhood obesity is increasing rapidly, not only in industrialized but also in developing countries in transition. It is cause for alarm that it commonly leads to adult obesity. Adult obesity is already endemic in most industrialized countries and is rapidly increasing in the more advanced developing countries as well. The result is an increase in morbidity and mortality from diabetes, hypertension, coronary heart disease, and other chronic diseases. The implications for developing countries are more serious because of evidence that fetal and infant malnutrition increases susceptibility to these chronic diseases in adults. There is an urgent need for a comprehensive compilation of available information as a basis for combating the epidemic of adult obesity.

Both authors are world authorities on exercise physiology and have applied their expertise to such a treatise. The first 11 chapters review in detail the main characteristics of childhood obesity, including epidemiology, stages of development, physical characteristics, energy expenditure and activity, evaluation of functional status, food intake, biochemical and hormonal characteristics, psychological aspects, and health problems.

The second section on treatment and management principles begins with a valuable 55-page chapter on the effects of various reduction therapies, followed by 35 pages on practical measures for weight management during the growing years. This book provides a wealth of well-presented and valuable information for all who are interested in this increasingly important subject.

Proteins of iron metabolism. Ugo Testa. CRC Press, Boca Raton, Fla., USA, 2002 (ISBN 0-8493-8676-4) 559 pages, hardcover, US$199.95/£134.00.

Iron is required for multiple metabolic processes in living organisms, from the most simple to the most complex. It is an essential component of hundreds of enzymes and is necessary for most body functions, from muscle activity to cognition. Iron is essential for oxygen transport, DNA synthesis, and electron transport, the heme moiety of hemoglobin, and many other functions. However, too much iron has toxic effects because of its capacity to react with oxygen to form hydroxyl radicals that damage proteins and nucleic acids. The mechanisms for the maintenance of iron homeostasis to assure the required release of iron to sustain biochemical activities, while avoiding the harmful effects of excessive iron absorption, are therefore of the utmost importance to survival and health.

Mammals have developed highly effective mechanisms for regulating the absorption of iron according to need, and for withholding iron from invading microorganisms. These processes are controlled by a number of different genes, and hemochromatosis is an autosomal recessive disease. A number of specialized tissues are involved, including duodenal enterocytes, hepatocytes, monocytes, and macrophages. This very comprehensive and well-integrated book, written by a single author, explores all of these issues with authority and in great depth.

Chapter topics include iron absorption, iron and cell proliferation mechanisms, lactoferrin, transferrin, transferrin receptors, soluble transferrin receptors, alternative iron uptake systems, iron-responsive elements and iron regulatory proteins, and ferritin. The references are extensive and the index is good. It is unfortunate that the book's cost will make it difficult for developing-country libraries to obtain it, since it is a valuable reference on a topic of major importance to them.

Rice to feed the world: Life and work of H. M. Beachell. Compiled and edited by Anwar Dil. Intercultural Forum, San Diego, Calif., USA, 2001 (ISBN 0-9640492-8-7) 559 pages, hardcover. US$50.00.

This is an exceptional collection of scientific articles and essays, most of them written by the subject of this book, Dr. Henry M. Beachell, the 1996 World Food Prize Laureate for his remarkable contributions to breeding better rice for Asia. However, it also includes selected writings by others on his work and detailed biographic information. Nutritionists and agriculturalists will find this book inspiring.

Seeds of contention: World hunger and the global controversy over GM crops. Per Pinstrup-Andersen and Ebbe Schiøler. Johns Hopkins University Press, Baltimore, Md., USA, 2001 (ISBN 0-8018-6826-2) 164 pages, paperback. US$12.95.

The world media are filled with controversy over the use of genetic engineering in food and agriculture. This small paperback by the Director of the International Food Policy Research Institute (IFPRI) and his colleague Ebbe Schiøler presents an appraisal of the evidence and considers the interests of developing countries. They recognize and attempt to evaluate the many questions, doubts, and concerns. They consider whether this technology can safely improve the quality of the food we eat, increase agricultural productivity, and be of benefit to the poor populations of developing countries. The passionate critics of genetically modified foods will not be satisfied with the even-handed approach of the authors, but those seeking a science-based middle ground will find it helpful in clarifying the issues and promoting a better understanding of them.

A study of factors influencing operational issues for iron supplements for infants and young children. Edited by Alizon Draper and Penelope Nestel. ILSI Press, Washington, D.C., 2001 (ISBN 1-577881-104-X) 97 pages, paperback.

This report is based on studies carried out in Ghana, Nepal, Peru, and Sri Lanka. Their aim was to explore the behavioral and sociocultural factors influencing the acceptability and use of iron-containing supplements for infants and young children below five years of age. Project staff gathered and synthesized the data from each site, and the results are described in separate chapters for each country. Penelope Nestel provided project oversight, and Alizon Draper was the technical advisor.

The studies show that current health and nutrition education has not been effective in giving women any concept of prevention. The women's emphasis on food suggests that an integrated food-based approach may be more effective than a pharmaceutical micronutrient supplement. The report contains an integrated analysis of the findings and a series of recommendations based on them. Further operational research will be required to assess the acceptability of and adherence to any form of iron supplementation or food fortification in these countries.

The complete text of this and many other related publications on iron deficiency and its prevention are available on the website of the Iron Deficiency Program Advisory Service (IDPAS) at *www.micronutrient.org/idpas*.

News and notes

Bellagio Conference on the Nutrition Transition in the Developing World and Its Health Implications

The Bellagio Conference on the Nutrition Transition in the Developing World and Its Health Implications has published its papers in the February 2002 issue of *Public Health Nutrition*. Free pdf versions of these papers can be downloaded by going to the world wide web address for the Nutrition Transition program *www.nutrans.org* and then clicking on the Bellagio Conferences papers.

Sight and Life Newsletter

For those interested in vitamin A deficiency, the *Bulletin* recommends the *Sight and Life Newsletter* published by the Task Force Sight and Life, P.O. 2116, 4002 Basel, Switzerland. Tel. 41 61 688 7494; Fax 41 61 688 1910; e-mail *sight.life@roche.com*. The newsletter and other information may be accessed at *www.sightandlife.org*.

Note for contributors to the *Food and Nutrition Bulletin*

The editors of the *Food and Nutrition Bulletin* welcome contributions of relevance to its concerns (see the statement of editorial policy on the inside of the front cover). Submission of an article does not guarantee publication—which depends on the judgement of the editors and reviewers as to its relevance and quality. All potentially acceptable manuscripts are peer-reviewed. Contributors should examine recent issues of the *Bulletin* for content and style.

Language. Contributions should be submitted in English.

Format. Manuscripts should be typed or printed on a word processor, **double-spaced**, and with ample margins. Authors are encouraged to submit manuscripts electronically, but original tables and figures must be sent by mail or courier. If not sent electronically, a **diskette** should accompany the manuscript.

Abstract. An abstract of not more than 250 words should be included with the manuscript, stating the purposes of the study or investigation, basic procedures (study subjects or experimental animals and observational and analytical methods), main findings (give specific data and their statistical significance, if possible), and the principal conclusions. Emphasize new and important aspects of the study or observations. Do *not* include any information that is not given in the body of the article. Do not cite references or use abbreviations or acronyms in the abstract.

Key words. Provide a minimum of four key words for the article.

Tables and Figures. Tables and figures should be on separate pages. Tables should be typed or printed out double-spaced. Submit only original figures, original line drawings in India ink, or glossy photographs. Labels on the figures should be typed or professionally lettered or printed, not handwritten.

Photographs. Ideally photographic materials should be submitted in the form of black and white negatives or white glossy prints. Photographs will not be returned unless a specific request is made.

Units of measure. All measurements should be expressed in metric units. If other units are used, their metric equivalent should be indicated.

Abbreviations. Please explain any abbreviations used unless they are immediately obvious.

References. References should be listed at the end of the article, also double-spaced. Unpublished papers should not be listed as references, nor should papers submitted for publication but not yet accepted.

Number references consecutively in the order in which they are first mentioned in the text. Identify references in the text and tables and figure legends by arabic numerals enclosed in square brackets. References cited only in tables or figure legends should be numbered in accordance with the first mention of the relevant table or figure in the text. **Be sure references are complete**.

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—standard journal article (list all authors):

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

—corporate author:

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

Book or other monograph reference

—personal author(s):

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

—corporate author:

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

—editor, compiler, chairman as author:

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

—chapter in book:

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

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Contributions should be addressed to:

Dr. Nevin S. Scrimshaw, Editor
Food and Nutrition Bulletin
115 Sandwich Notch Rd.
PO Box 330
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E-mail: nevin@cyberportal.net

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