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The Food and Nutrition Bulletin encourages letters to the editor regarding issues dealt with in its contents.
Carotenoid-rich bananas: A potential food source for alleviating vitamin A deficiency

Lois Englberger, Ian Darnton-Hill, Terry Coyne, Maureen H. Fitzgerald, and Geoffrey C. Marks

Editor's note

As vitamin A and carotenoids are inextricably bound by precursor or provitamin/vitamin status, newer research on the bioavailability and conversion of dietary carotenoids to retinol takes on increasing importance. The recent edition of the Dietary Reference Intakes (DRIs) in the United States adds a suggestion to our nomenclature in this regard with the use of retinol activity equivalent (RAE), which reflects newer data on bioconversion. The Food and Nutrition Bulletin will note the alternative conversion where appropriate as an aid to our readers. We invite readers' comments on this issue.

Abstract

This review article points out that bananas are an important food for many people in the world. Thus, banana cultivars rich in provitamin A carotenoids may offer a potential food source for alleviating vitamin A deficiency, particularly in developing countries. Many factors are associated with the presently known food sources of vitamin A that limit their effectiveness in improving vitamin A status. Acceptable carotenoid-rich banana cultivars have been identified in Micronesia, and some carotenoid-rich bananas have been identified elsewhere. Bananas are an ideal food for young children and families for many regions of the world, because of their sweetness, texture, portion size, familiarity, availability, convenience, versatility, and cost. Foods containing high levels of carotenoids have been shown to protect against chronic disease, including certain cancers, cardiovascular disease, and diabetes. Because the coloration of the edible flesh of the banana appears to be a good indicator of likely carotenoid content, it may be possible to develop a simple method for selecting carotenoid-rich banana cultivars in the community. Research is needed on the identification of carotenoid-rich cultivars, targeting those areas of the world where bananas are a major staple food; investigating factors affecting production, consumption, and acceptability; and determining the impact that carotenoid-rich bananas may have on improving vitamin A status. Based on these results, interventions should be undertaken for initiating or increasing homestead and commercial production.

Key words: Banana, carotenoids, chronic disease, community nutrition, cultivar differences, staple foods, vitamin A, vitamin A deficiency

Introduction

Vitamin A deficiency is considered a priority among global health problems [1–3], since it can be related to increased mortality among children and women, particularly in developing countries [4, 5]. The underlying cause of vitamin A deficiency is a lack of vitamin A in the diet. Food sources of vitamin A include animal foods rich in vitamin A (retinol) and plant foods containing provitamin A carotenoids, such as β-carotene, the carotenoid contributing most to vitamin A status [6]. Previous food-based strategies for decreasing vitamin A deficiency, such as horticultural programs and nutrition education, have focused on the production and promotion of vitamin A-rich foods, including eggs; milk; liver; dark-green leafy vegetables; orange and yellow fruits and vegetables such as papaya, mango, pumpkin, squash, carrot, and orange-fleshed sweet potatoes; red palm oil; and other foods such as buriti.
palm fruit and gac fruit, which are not known outside their home countries of Brazil and Vietnam [7–17]. Reference books and papers also list these foods as sources of vitamin A [4, 6, 18–24]. Only a few references list banana or plantain cultivars (Musa spp.) as good sources of vitamin A (a cultivar refers to a variety produced by cultivation) [25–28]. A major vitamin A resource book lists bananas as a poor source of vitamin A [10]. This would be a correct statement with reference to bananas analyzed in the United States and United Kingdom, which contain 21 µg of β-carotene/100 g [29, 30]. Although the US and UK bananas are not documented by cultivar name, they are most likely Cavendish, the primary banana cultivar marketed globally [31]. As a result, people in developed countries are mostly familiar with Cavendish bananas. Internationally this cultivar accounts for 41% of all banana production [32]. However, there are over 30 banana species, with around 500 varieties having edible fruits, which make up the remaining world production (the total annual production is approximately 98 million tonnes) [31, 32]. Recently some banana cultivars rich in provitamin A carotenoids were identified in the Federated States of Micronesia [33–35]. One, Uhl en Yap, contains 6,110 µg of β-carotene/100 g, which is 275 times the level noted for Cavendish. The Pohnpei Karat banana, a traditional weaning food in the Federated States of Micronesia [36], contains 867 µg of β-carotene/100 g (average of several samples analyzed by two laboratories) [37]. Some Southeast Asia banana cultivars contain 300 to 400 µg of β-carotene/100 g [38–40]. These commonly eaten bananas have over 10 times the β-carotene level of the common Cavendish.

This paper reviews difficulties with the present food-based vitamin A deficiency–prevention strategies and the foods being promoted. (Breastmilk is an important source of vitamin A for breastfed children, but this paper discusses vitamin A–rich foods that are complementary to breastmilk or that are eaten by older children and adults.) It sets forth an argument as to why consumption of carotenoid-rich banana cultivars may be a meaningful alternative that could have a significant impact on improving vitamin A status and general health in many areas of the world. The increase in consumption of carotenoid-rich bananas among children and women is targeted due to their vulnerability to vitamin A–deficiency disorders.

Factors limiting the potential of known food sources of vitamin A

There have been successes in strategies that focus on previously identified foods for alleviating vitamin A deficiency, which indicates the importance of continuing such programs [8, 9, 14, 41–46]. However, there are a number of factors that appear to limit the production or consumption of certain of these foods.

Animal foods

Animal foods as sources of vitamin A are often too expensive for low-income people, unacceptable for religious reasons, or less available [6, 13, 19, 21, 41, 47–54]. In many countries, there are cultural beliefs restricting egg consumption among children and women of child-bearing age; for example, eggs (or other protein foods) may be avoided in pregnancy to restrict fetal growth and avoid difficult deliveries [55, 56], and some people believe that feeding eggs to children can cause death [57] or that giving eggs to children under 18 months of age may prevent them from talking [58]. In many countries, cow’s milk and its products are often not consumed for various reasons, including lack of availability in the past, cost, lactose intolerance, perception of milk as an unpleasant secretion, and the idea that it is a food for calves only [37, 48, 55, 59, 60]. Chickens’ eggs and cow’s milk are common food allergens in children [61, 62]. Liver is often not liked because of its taste or texture. In one study on young children’s food preferences, liver was the most disliked of any meat [63]. Nevertheless, it is difficult to reverse a deficient state without the use of animal sources of vitamin A or supplements [23].

Dark-green leafy vegetables

In many regions of the world, dark-green leafy vegetables may not be given to young children, particularly those under one year of age, because of concern that children may not be able to digest them and might develop indigestion, diarrhea, or severe sicknesses, or that an illness might worsen [27, 57, 58, 64–70]. In many countries, children are allowed much control over what they eat [36, 51, 71, 72]. Children often do not like the bitter taste and coarse texture of dark-green leafy vegetables and therefore often refuse to eat them [13, 19, 21, 66, 73]. The usual portion size of dark-green leafy vegetables that is eaten may be too small to meet the estimated vitamin A requirements [6, 68, 69, 74–76]. Perhaps more importantly, recent research has shown that the provitamin A carotenoids of dark-green leafy vegetables do not contribute to vitamin A status as much as was once thought [77–80]. In addition, there are carotenoid losses (as with other vegetables and fruits) in handling, preservation, and cooking [48, 54, 81].

Dark-green leafy vegetables, particularly certain types, are often associated with poverty and, hence, are often considered low-status foods or even foods for animals, making the promotion of these foods very difficult [21, 27, 37, 48, 64–66, 68, 82–84]. Excessive time may be needed for gathering dark-green leafy veg-
etables, especially those gathered from the wild [48, 84, 85]. Among some people, dark-green leafy vegetables may not be considered food for humans [37, 86–88] or may not be regularly eaten [41, 89]. In Indonesia, pregnant women may avoid increased consumption of food, including dark-green leafy vegetables, in order to restrict fetal growth, which is thought to lead to easier deliveries [69]. In Nepal, pregnant and lactating women often avoid dark-green leafy vegetables because they think that babies of women who eat them will be born green or yellow and that lactating women will experience swelling [57].

For some people, there are major obstacles to growing dark-green leafy vegetables (and other vegetables), including the cost of fencing, nonavailability of planting material or seeds, limited land availability, women's workloads, and inadequate water supply [82, 89–95]. Gardening in urban slums is possible but difficult [46]. Nevertheless, by increasing the number of varieties grown, small home gardens have been able to significantly increase vitamin A intake and help reduce night-blindness [46].

**Papaya**

Papaya is avoided by many in southern India because of a widespread and strong belief that a pregnant woman will have a miscarriage if she eats it [48, 52, 76, 96]. Some people in India see it as a food that causes dysmenorrhea in women and impotence in men [48]. In one African country, women avoid papaya because it is associated with worms, which are thought to cause sterility [55]. Many people do not like ripe papayas and consider them food for pigs, chickens, or wild birds [26, 37] or baby food [36, 37]. Many people prefer eating green papayas, which have little carotenoid content [25, 37, 38, 55, 97–99]. Papayas (and mangoes) were rarely eaten by preschool children in a study in Malawi [100]. In rural Bangladesh, papayas were rarely eaten by mothers in a seven-month study [101]. Papayas are seasonal in some areas or may not be grown [10, 48, 64]. When people grow their own papayas, theft of the fruits is sometimes a problem [82]. Papayas may be prohibitive in price for many people [13, 37].

Furthermore, the carotenoid content of many cultivars of papaya is low. West and Poortvliet showed that most cultivars contain less than 300 µg of β-carotene/100 g [102]. Six of the 10 ripe papaya entries had less than 100 retinol equivalents (RE)/100 g [102], which is the cutoff value used by Helen Keller International to define vitamin A–rich foods [103].

One cultivar contained 71 µg of β-carotene/100 g (total RE value, 32 µg/100 g, which included β-cryptoxanthin content, the other major provitamin A carotenoid in papaya). Other studies have also reported papaya cultivars with low carotenoid values [6, 38, 104, 105].

**Mango**

Ripe mangoes generally have a higher provitamin A content than papayas, although some cultivars contain less than 100 µg RE/100 g [102]. However, mangoes are seasonal and may be available for only two months in the year, they are relatively expensive for many people [13, 21, 25, 37, 106], and the usual portion size is less than the amount needed for the estimated vitamin A requirements for a young child [75]. Mangoes, like papayas, may often be eaten green, at the stage of maturation in which the carotenoid content is low [37, 38, 54, 85]. Some lactating mothers do not eat mangoes because they believe that lactating mothers who eat mangoes (and pumpkins) will have babies with yellow skin [107]. Fibrous mangoes can cause diarrhea in infants if fed in large quantities (although small slices do not) [81]. Mangoes can also cause serious allergic reactions [108].

**Other plant sources of vitamin A**

Pumpkins and squash have been reported to be hard to store, seasonal, expensive, and either unpopular or unfamiliar vegetables [37, 52, 81, 109]. Some people believe that pumpkins can exacerbate illnesses such as measles, diarrhea, and protein–energy malnutrition and that pregnant women must avoid pumpkins to prevent colds and diarrhea [57]. Carrots are still not commonly available in many developing countries [6, 54, 109], or they may be expensive and purchased only for festive occasions [48, 52]. In some tropical areas, carrots do not grow because of the hot climate [37]. Tomatoes are sometimes listed as a source of vitamin A, but the content of vitamin A varies among tomato cultivars, some containing minimal levels of vitamin A (the red color is from lycopene, a carotenoid with no vitamin A activity) [6, 48].

Orange-fleshed sweet potatoes have important potential as a staple food for improving vitamin A status in Africa [9, 110] and the Pacific [111] and have been shown to raise serum retinol levels in young children [112]. The challenge remains in introducing the new varieties to other areas that grow sweet potatoes. Because sweet potatoes are considered a woman's crop in Africa (and other communities), there is the limitation of women's workloads [9, 110]. Moreover, sweet
Agriculture Organization (FAO) reports [126] and FAO have both been classified as fruits in global Food and interpretations of studies on “banana” and global that care is needed in communications about bananas the use of the terms differs among countries, indicating or ripe. Plantains are usually eaten cooked. However, eaten as ripe raw fruit or cooked as a staple food, green are commonly more starchy at ripeness. Bananas are plantain [125]. Plantains are just types of bananas that maize [124]. The term “banana” as used here includes most important food in the world, after rice, wheat, and cooked staple foods. This underestimates their use as staple foods and presents a particular challenge in the interpretation of global data on the production and consumption of these foods.

More than 400 million people in developing countries consume bananas as a staple food; 100 million of these people are in Africa [124]. The greatest diversity of bananas is in Southeast Asia, including Papua New Guinea, where bananas are believed to have their origin [124, 125]. This is reflected by a number of banana cultivars in the food-composition tables in that region: 8 Thai [39], 19 Malaysian [40], and 11 Philippine banana cultivar entries [38]. The two secondary centers of banana diversity in the world are West and Central Africa and the East African Highlands [31]. In Uganda, Burundi, and Rwanda, banana consumption is from 250 to 400 kg per person per year (3 to 11 bananas daily, depending on the size of the bananas) [124, 125, 127].

The main export areas are in Central and South America and the Philippines. There are 12.7 million tonnes of bananas in world trade, worth US$4,306 million [32]. However, this represents only about 13% of the bananas grown worldwide. The remainder is grown in household gardens for home consumption and local trade [32, 124, 128]. Farmers are also likely to grow a diversity of cultivars, which has been important in the past for disease control, climate adaptation, and provision of a variety of tastes and nutrients [37, 129]. Bananas have been called a “humble” food and a “poor man’s food” [37, 130–132], indicating their importance for low-income people and a common cultural attitude toward bananas.

Vitamin A deficiency is common in areas where bananas are grown as a staple food crop [133]. A shift from low-carotenoid to high-carotenoid banana cultivars would lead to increased vitamin A content of the diet and thus possibly lead to improved vitamin A status in those areas. The Micronesian high-carotenoid bananas are well liked for their good taste, and a number of them have been eaten for many years, indicating high acceptability [34] (see also the section on the Karat banana). McLaren suggested that for understanding the cause of vitamin A deficiency, investigation of the staple food eaten is important, particularly since rice-eating communities are prone to vitamin A deficiency disorders [6]. Bouis argued that the strategy of improving the vitamin and mineral content of staple foods has several advantages: little behavioral change on the part of the people is required, and large amounts of these foods are consistently eaten on a daily basis by all family members [134]. There has been considerable success in the introduction of orange-fleshed sweet potatoes in parts of Africa [9, 110], providing an example of a successful shift from a low-carotenoid to a high-carotenoid staple food cultivar [135].

Bananas: Scope for a significant impact on global health

Given some of the issues associated with the production and consumption of foods that are the current focus of many nutrition programs to alleviate vitamin A deficiency and the lack of success of many of these programs, we suggest that consideration be given to the promotion of carotenoid-rich banana cultivars in communities where they could be readily available and culturally acceptable as human food.

Bananas: A major staple food

Bananas, a major global food staple, are the fourth most important food in the world, after rice, wheat, and maize [124]. The term “banana” as used here includes plantain [125]. Plantains are just types of bananas that are commonly more starchy at ripeness. Bananas are eaten as ripe raw fruit or cooked as a staple food, green or ripe. Plantains are usually eaten cooked. However, the use of the terms differs among countries, indicating that care is needed in communications about bananas and interpretations of studies on “banana” and global “banana” production data [125]. Bananas and plantains have both been classified as fruits in global Food and Agriculture Organization (FAO) reports [126] and FAO Food Balance Sheets, although they are both eaten as cooked staple foods. This underestimates their use as staple foods and presents a particular challenge in the interpretation of global data on the production and consumption of these foods.

Refined red palm oil has acceptable organoleptic characteristics (taste and smell) and the potential to provide needed fat, energy, and other nutrients and phytochemicals in the diet that may decrease heart disease and cancer [13, 114–116]. Red palm oil has been shown to improve vitamin A status in children and women [4, 116–118]. Its use as a traditional food has spread from West Africa [119, 120] to other parts of Africa and many other countries in Asia, especially Malaysia, and to South America [113, 120, 121]. However, crude red palm oil is disliked for its taste, smell, and red color. When it is processed to remove the color and the distasteful characteristics, the vitamin A activity is lost, except when processed by a new method now used in Southeast Asia. Refined red palm oil (Carotino) has several obstacles to acceptability, including its red color, competition from locally established oils, cost, and concern about its saturated fatty acid content [4, 106, 121, 122].

The buriti palm fruit from Brazil and the gac fruit from Vietnam have very high levels of provitamin A carotenoids and have been shown to improve vitamin A status [4, 17, 21, 113, 125], but these plant products are still not widely known or available. The oily gac fruit is not normally eaten as a food, but it has been used in Vietnam to impart coloring and flavor [17].

Potatoes are not a major food in many countries [54, 91, 113].

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Work is also being carried out on plant-breeding strategies to increase the nutrient density of β-carotene, iron, and zinc in wheat, rice, maize, cassava, and the common bean [136]. Golden rice is rice that has been genetically modified to increase its β-carotene content. Nonmodified rice normally contains no provitamin A carotenoids and is the staple food eaten by most societies that have the worst vitamin A deficiency.

Golden rice was developed as a solution to vitamin A deficiency, but there are questions about the acceptability of rice with a different color [137]. Some analyses suggest that golden rice is relatively low in carotenoid content and could meet only 6% to 12% of the estimated vitamin A requirements for infants and small children [138]. This calculation is based on the assumption that the conversion of dietary β-carotene to vitamin A in the rice would be at the standard ratios (12:1 or 6:1). However, the rice matrix is known to be very digestible. Thus, the bioavailability may be much higher. The β-carotene bioavailability in banana may be higher than the 12:1 or 6:1 ratio, because the banana matrix is almost totally digestible. However, this has not yet been demonstrated.

Virtually all people do not choose their food for its vitamin A content but eat what they like and what is most available [37, 67, 139, 140]. People often do not associate the concept of nutrition and diet with illness or good growth [50, 139, 141, 142]; some believe that illness is contracted because of supernatural or other events [36, 50, 90, 143–145], making it more difficult to effect dietary change on the basis of a healthier diet.

Table 1 presents the β-carotene and α-carotene content of ripe Micronesian banana cultivars and their possible impact on vitamin A requirements [146] according to different consumption levels. The daily amount of local starch foods traditionally eaten by an adult Pacific Islander is estimated at 750 to 1,000 g [111], and thus it is reasonable that bananas could be eaten at this level of consumption. Thirteen banana cultivars were identified in Micronesia that contain significant levels of the provitamin A carotenoids β-carotene and α-carotene [37], meeting half or all of the estimated vitamin A requirements for a nonpregnant, nonlactating woman. Some can also meet the estimated vitamin A requirements for young children. One banana, Karat, was also analyzed separately for the provitamin A carotenoid β-cryptoxanthin and was found to contain 35.6 µg/100 g [147].

Table 2 presents the β-carotene and α-carotene contents of selected banana cultivars from Southeast Asia to show examples of carotenoid-rich cultivars from those areas and to show the range in carotenoid content.

As noted earlier, recent research has shown that β-carotene from some plant sources has a lower bioavailability than was once thought; e.g., dark-green leafy vegetables might provide only 1 µg of vitamin A from 26 µg of β-carotene [78]. Previously it was accepted that dark-green leafy vegetables had a greater bioavailability, providing the same amount of vitamin A from a smaller amount of β-carotene (6 µg). However, the bioavailability of β-carotene in orange and yellow fruits and tubers has been found to be greater than that in dark-green leafy vegetables, and the ratios have now been set at 12 µg of β-carotene to 1 RAE and 24 µg of other provitamin A carotenoids to 1 RAE [78, 80]. Thus, it is likely that orange and yellow-orange colored bananas would have a significant impact on improving vitamin A status.

**Karat and other banana cultivars**

Two of the carotenoid-rich cultivars from the Federated States of Micronesia, Karat and Uht en Yap, are Fe’i bananas, sometimes referred to as Musa tropoglydratum or Musa (Australimusa Series) [148]. These bananas are characterized by an erect bunch (fig. 1) and red sap [149, 150]. The fruits and bunches have varying shapes and appearances (figs. 2 and 3). Different types of Fe’i bananas have been reported in other Pacific islands, including Papua New Guinea, Fiji, Rotuma, Tahiti, and Tonga [149–153]. Another Fe’i cultivar analyzed, the Samoa Soa’a, had a relatively low carotenoid content (108 µg of β-carotene equivalents/100 g) [154].

Karat has been eaten in Micronesia for hundreds of years. A study of flora was carried out in Kosrae, one of the four Federated States of Micronesia, in the 1830s [155]. At that time four banana cultivars were documented: Usr Kulasr (Kosraean for Karat), Usr Kolontol (Uht en Yap in Pohnpei), and two non-Fe’i cultivars, Usr Wac and Usr Karia. All four cultivars are carotenoid-rich (table 1). Informants emphasize that there was greater consumption of these in the past.

FIG. 1. Fe’i banana plant (Karat) with erect bunch.
Although Karat, a traditional weaning food in the Federated States of Micronesia, had been neglected, it has been recently promoted in Pohnpei State. Following a one-year campaign in 1999, production increased and the cultivar was then marketed, although it had not been marketed prior to the campaign, showing that even short-term food-based campaigns can be successful if planned carefully, taking cultural beliefs and practices into account [43]. Apparently vitamin A deficiency is a new problem in the Federated States of Micronesia [156, 157]. Thus, these banana cultivars may have protected against vitamin A deficiency in the past and could again play important roles in preventing vitamin A deficiency [37, 157]. We suggest the same could occur in other communities.

**Other potential health benefits**

Epidemiological studies suggest that carotenoid-rich food protects against chronic diseases, including certain cancers, cardiovascular disease, diabetes, some inflammatory diseases, and age-related macular degeneration [158–161]. This is in contrast to two studies showing that β-carotene as a supplement had harmful effects by producing more lung cancers [162, 163]. Consumption of carotenoid-rich bananas should help protect against those diseases, which are growing problems throughout the world [164–166]. Increased consumption of carotenoid-rich foods may be more likely if they are promoted for protection against both vitamin A deficiency disorders and chronic diseases, since chronic diseases are more visible in the community.

---

**TABLE 1. Comparison of ripe Micronesian banana cultivars for impact on vitamin A requirements according to level of consumption**

<table>
<thead>
<tr>
<th>Local name&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Classification&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Color&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Sample&lt;sup&gt;d&lt;/sup&gt;</th>
<th>N&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Laboratory&lt;sup&gt;f&lt;/sup&gt;</th>
<th>β-Carotene eq&lt;sup&gt;g&lt;/sup&gt; (µg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uht en Yap/Usr Kolonteh&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>Fe’i</td>
<td>Orange</td>
<td>Baked</td>
<td>3</td>
<td>I, R</td>
<td>4,960</td>
</tr>
<tr>
<td>Ust Wac&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>AAB; plantain-like</td>
<td>Orange</td>
<td>Boiled</td>
<td>2</td>
<td>I, R</td>
<td>2,598</td>
</tr>
<tr>
<td>Ipah&lt;sup&gt;h,i,j&lt;/sup&gt; = Usr Wac Es Sie</td>
<td>AAB; plantain-like</td>
<td>Orange</td>
<td>Boiled</td>
<td>2</td>
<td>I, R</td>
<td>1,349</td>
</tr>
<tr>
<td>Ust Kariah&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>NA</td>
<td>Yellow</td>
<td>Steamed</td>
<td>1</td>
<td>I</td>
<td>892</td>
</tr>
<tr>
<td>Karat/Usr Kalass&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>Fe’i</td>
<td>Yellow-orange</td>
<td>Steamed or boiled</td>
<td>3</td>
<td>I, R</td>
<td>867</td>
</tr>
<tr>
<td>Ust Wac Es Sie&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>AAB; plantain-like</td>
<td>Yellow-orange</td>
<td>Steamed</td>
<td>1</td>
<td>I</td>
<td>859</td>
</tr>
<tr>
<td>Ust Macah&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>AA; Lakatan</td>
<td>Yellow-orange</td>
<td>Boiled</td>
<td>2</td>
<td>I, R</td>
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<td>Mangar&lt;sup&gt;h,i&lt;/sup&gt;</td>
<td>AAA; Green Red</td>
<td>Yellow</td>
<td>Raw</td>
<td>1</td>
<td>C</td>
<td>773</td>
</tr>
<tr>
<td>Ust Taiwang&lt;sup&gt;h,i,j&lt;/sup&gt;</td>
<td>AAB; Pisang Kelat</td>
<td>Yellow</td>
<td>Boiled</td>
<td>1</td>
<td>R</td>
<td>490</td>
</tr>
<tr>
<td>Uht en Kerini&lt;sup&gt;h,i&lt;/sup&gt;</td>
<td>AAB; Pisang Raja</td>
<td>Yellow</td>
<td>Raw</td>
<td>1</td>
<td>I</td>
<td>415</td>
</tr>
<tr>
<td>Ust in Yeih&lt;sup&gt;h,i&lt;/sup&gt;</td>
<td>AAB; Pisang Mysore</td>
<td>Yellow</td>
<td>Boiled</td>
<td>2</td>
<td>I, R</td>
<td>390</td>
</tr>
<tr>
<td>Marech</td>
<td>NA</td>
<td>Yellow</td>
<td>Raw</td>
<td>1</td>
<td>I</td>
<td>232</td>
</tr>
<tr>
<td>Ust Apat Poel/Uht Inasio</td>
<td>ABB; Bluggoe</td>
<td>Creamy</td>
<td>Boiled</td>
<td>1</td>
<td>R</td>
<td>155</td>
</tr>
<tr>
<td>Uht en Ruk/Ust Apat Fusus</td>
<td>ABB; Saba</td>
<td>Creamy</td>
<td>Boiled</td>
<td>3</td>
<td>R</td>
<td>148</td>
</tr>
<tr>
<td>Ust Fiji/Uht en Fiji</td>
<td>ABB; Mysore</td>
<td>White</td>
<td>Raw</td>
<td>1</td>
<td>I</td>
<td>77</td>
</tr>
<tr>
<td>Ust Kafa/Bt en Menihla</td>
<td>ABB; Silk</td>
<td>White</td>
<td>Raw</td>
<td>1</td>
<td>R</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: refs. 33 and 34 for all data except for those on Mangat, for which data are from ref. 35. NA, Not available. Daily vitamin A recommended safe women 19–65 years of age; 400 µg RE for children 1–3 years of age. 450 µg RE for children 4–6 years of age. β-Carotene equivalents are defined as equivalent (RE) is 1 µg of all-trans-retinol defined to equal 6 µg of all-trans-β-carotene, and a retinol activity equivalent (RAE) is 1 µg of all-trans-

- a. Pohnpei, Kosrae, or Chuuk names are given; for cultivars having different names, the name presented first is for the sample analyzed or that for b. The Stover and Simmonds [148] classification by genome and subgroup is used.
- c. Color of edible portion was identified by visual comparison.
- d. The cooking method used in preparing the sample is given. If no cooked sample was analyzed for the cultivar, the results of analysis of the raw sample is given.
- e. The number of duplicate analyses of composite samples from which β-carotene equivalents were calculated is given. Most composite samples by less than 10% from each other (Fiji laboratory); the standard error of the mean for the Swiss analyses ranged from 8.5% to 9.4%.
- f. The following laboratories carried out the analyses: I, Institute of Applied Sciences/University of the South Pacific, Suva, Fiji; R, Roche Vitamins, Basel, Switzerland; C, Covance Laboratories, Madison, Wisconsin, USA.
- g. β-Carotene equivalents were calculated from averages of the β-carotene, and a retinol activity equivalent (RAE) is 1 µg of all-trans-
- h. Cultivar providing half or more of the daily vitamin A requirement for nonpregnant, nonlactating women 19–65 years of age, if 1,000 g (4 cups) of edible portion is eaten/day.
- i. Cultivar providing half or more of the daily vitamin A requirement for a child from 4 to 6 years of age, if 500 g (2 cups) of edible portion is eaten/day.
- j. Cultivar providing half or more of the daily vitamin A requirement for a child from 1 to 3 years of age, if 250 g (1 cup) of edible portion is eaten per day.
- k. This cultivar, called Uht Akatan or Ust Lakatan in the Federated States of Micronesia, is different from the Lakatan in the Philippines because of...
### TABLE 1. Comparison of ripe Micronesian banana cultivars for impact on vitamin A requirements according to level of consumption

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>µg RE (if 1,000 g eaten/day)</th>
<th>µg RE (if 500 g eaten/day)</th>
<th>µg RE (if 250 g eaten/day)</th>
<th>µg RAE (if 1,000 g eaten/day)</th>
<th>µg RAE (if 500 g eaten/day)</th>
<th>µg RAE (if 250 g eaten/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8,267</td>
<td>4,133</td>
<td>2,067</td>
<td>4,133</td>
<td>2,067</td>
<td>1,033</td>
</tr>
<tr>
<td></td>
<td>4,330</td>
<td>2,165</td>
<td>1,083</td>
<td>2,165</td>
<td>1,083</td>
<td>541</td>
</tr>
<tr>
<td></td>
<td>2,248</td>
<td>1,124</td>
<td>562</td>
<td>1,124</td>
<td>562</td>
<td>281</td>
</tr>
<tr>
<td></td>
<td>1,487</td>
<td>743</td>
<td>372</td>
<td>743</td>
<td>372</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>1,445</td>
<td>723</td>
<td>361</td>
<td>723</td>
<td>361</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>1,431</td>
<td>716</td>
<td>358</td>
<td>716</td>
<td>358</td>
<td>179</td>
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<tr>
<td></td>
<td>1,395</td>
<td>698</td>
<td>349</td>
<td>698</td>
<td>349</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>1,288</td>
<td>644</td>
<td>322</td>
<td>644</td>
<td>322</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>958</td>
<td>479</td>
<td>240</td>
<td>479</td>
<td>240</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>816</td>
<td>408</td>
<td>204</td>
<td>408</td>
<td>204</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>692</td>
<td>346</td>
<td>173</td>
<td>346</td>
<td>173</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>650</td>
<td>325</td>
<td>163</td>
<td>325</td>
<td>163</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>387</td>
<td>193</td>
<td>97</td>
<td>193</td>
<td>97</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>258</td>
<td>129</td>
<td>65</td>
<td>129</td>
<td>65</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>247</td>
<td>123</td>
<td>62</td>
<td>123</td>
<td>62</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>128</td>
<td>64</td>
<td>32</td>
<td>64</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>33</td>
<td>17</td>
<td>33</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

### Notes

The following laboratories carried out the analyses: I, Institute of Applied Sciences/University of the South Pacific, Suva, Fiji; R, Roche Vitamins, Basel, Switzerland; C, Covance Laboratories, Madison, Wisconsin, USA. Single analyses are presented.

The results of the duplicate analyses varied by less than 10% from each other (Fiji laboratory); the standard error of the mean for the Swiss analyses ranged from 8.5% to 9.4%.

The cooking method used in preparing the sample is given. If no cooked sample was analyzed for the cultivar, the results of analysis of the raw sample are presented.

The sum of the α-carotene and one-half the β-carotene content was calculated as equivalent (RE) is 1 µg of all-trans-β-carotene.

### Fe’si bananas (Karat)

Fe’si bananas (Karat), one unpeeled (far right) and one peeled (second from right), showing shape, size, and darker shades of skin and flesh compared to a common Micronesian banana, unpeeled (far left) and peeled (second from left).

### Other positive factors related to bananas as a crop and a food

Bananas are also a good source of energy, vitamin C, potassium, and fiber [19, 111, 124, 167] and therefore provide a variety of important nutrients for good health. Although the common banana is low in calcium, the Karat cultivar has a relatively high content of calcium [33].

**Other positive factors related to bananas as a crop and a food**

Bananas are a crop that is easy to grow in a tropical climate. They do not require replanting or seed purchase, and they generally bear fruit throughout the year, providing ongoing availability, unlike some other crops [124]. Although there is no “perfect banana cultivar,” when pest and disease resistance, yield, taste, and nutritional content are taken into consideration cultivars can be selected with the most positive characteristics that are suitable for the particular environment [168]. Fungal diseases (e.g., black Sigatoka) threaten global banana production, in particular that of the Cavendish cultivar [125], but some cultivars, including Karat, have been found to show resistance to these diseases [168], emphasizing the need to maintain a diversity of banana cultivars. Obtaining planting material may be difficult for rare banana cultivars, but banana tissue culture offers many advantages to ensure that cultivars are maintained free from dangers of the environment, pests, or disease. Tissue culture can provide planting material as pathogen-tested plantlets to be sent all over the world. A program in Kosrae has now started providing Karat (Usr Kalas) banana for their community [169].
TABLE 2. β-Carotene and α-carotene content of selected banana cultivars from Southeast Asia compared with the common banana

<table>
<thead>
<tr>
<th>Scientific namea</th>
<th>Local nameb</th>
<th>Origin</th>
<th>Ref.</th>
<th>Classification b</th>
<th>β-Carotene eq (µg/100 g)c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musa sapientum var. tuldoc</td>
<td>Tundok</td>
<td>Philippines</td>
<td>38</td>
<td>AAB; Horn Plantain</td>
<td>1,370</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Rajah Buluh</td>
<td>Malaysia</td>
<td>40</td>
<td>AAB; Pisang Raja</td>
<td>420</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Mas</td>
<td>Malaysia</td>
<td>40</td>
<td>AAB; Sucrier</td>
<td>420</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Tundok</td>
<td>Malaysia</td>
<td>40</td>
<td>AAB; Horn Plantain</td>
<td>370</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Kelat</td>
<td>Malaysia</td>
<td>40</td>
<td>AAB; Pisang Kelat</td>
<td>370</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Lakatan</td>
<td>Philippines</td>
<td>38</td>
<td>AA; Lakatan</td>
<td>360</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Khai Khai</td>
<td>Thailand</td>
<td>39</td>
<td>AA; Sucrier</td>
<td>345</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Susu</td>
<td>Malaysia</td>
<td>40</td>
<td>AAA; Pisang Susu</td>
<td>330</td>
</tr>
<tr>
<td>Musa sapientum var. ternantensis</td>
<td>Ternate</td>
<td>Philippines</td>
<td>38</td>
<td>AAB; Pisang Raja?</td>
<td>325</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Rajah Udang</td>
<td>Malaysia</td>
<td>40</td>
<td>AAA; Red</td>
<td>290</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Hug-mook, Silver Bluggoe</td>
<td>Thailand</td>
<td>39</td>
<td>ABB; Bluggoe</td>
<td>279</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Pisang Berangan</td>
<td>Malaysia</td>
<td>40</td>
<td>AA; Lakatan</td>
<td>230</td>
</tr>
<tr>
<td>Musa sp.</td>
<td>Common banana</td>
<td>Unspecified</td>
<td>29, 30</td>
<td>AAA; Cavendishd</td>
<td>21</td>
</tr>
</tbody>
</table>

a. The name provided in the reference is given.
b. The Stover and Simmonds [148] classification by genome and subgroup is used.
c. β-Carotene equivalents are defined as the sum of the β-carotene and one-half of the α-carotene content.
d. It is likely that the banana documented as the common banana in these references is the Cavendish.

Young children are fed bananas in many cultures because of their sweet taste and soft texture and because children seem almost universally to like them [56, 63, 107, 170–172]. Bananas have great versatility and are prepared in a variety of recipes, including baby food preparations, puddings, pancakes, and breads. In the Pacific, bananas are mixed with taro or yam, along with coconut cream, and baked in several recipes. Because they can be eaten raw, bananas provide a convenient food for busy mothers and a ready-to-eat, hygienically packed food for the child. Bananas can be considered a healthful “fast food.” Even when ripe bananas are cooked as a staple food, the cooking time is relatively short and they can be prepared without milling or grinding into flour, as must be done with cereal products.

The coloration of the edible portion of the banana fruit appears to be a good indicator of its carotenoid content [33, 34]. Five grades of color have been identified: white, creamy, yellow, yellow-orange, and orange. Thus, banana fruit coloration might be used in the community to select banana cultivars with the greatest potential for health benefits. However, further work is needed to verify that color does consistently reflect the carotenoid content in different banana cultivars.

Lack of data on composition of foods in the diet

Although the identification of vitamin A–rich foods is critical to food-based vitamin A deficiency programs [48, 102, 173], there are few data on the carotenoid content of many foods [21, 47, 48]. Table 3 presents information on many banana cultivars from Africa and other regions that are potentially carotenoid-rich, based on the reported yellow or orange coloration [174], and that thus may be good sources of vitamin A, depending on a number of factors, including the number of varieties and volume of production [46]. Another banana, Nendran of India [175], was described by Kerala informants to be similar in appearance to the Ipali of Pohnpei (table 1) and as having an orange-colored flesh. Nendran is a popular banana in Kerala and other parts of southern India, is widely eaten by people of all ages, is traditionally given to babies from four months of age, and is said to be good for the eyesight. In two studies carried out in India, Nendran was found to contain 310 and 336 µg of β-carotene/100 g [176, 177], which are high levels compared with those in the common banana. Indian food-composition tables provide data on carotenoid content for only the common banana [99]. The Champa of Bangladesh is reported to have a very yellow-colored flesh, but no known analyses have been done on this banana (Ahmed F, personal communication, 2003). The Pisang Raja, King Banana, was identified in an Indonesian study as one of the 47 foods contributing most of the vitamin A to the diet of 265 preschool children [178]. Such examples indicate the need for research on and awareness of the nutrient contents of selected banana cultivars.
Discussion and conclusions

The success of a food-based vitamin A deficiency-prevention strategy based on locally grown foods depends largely on the food that is promoted. Numerous factors limit the potential of presently known vitamin A–rich foods, including the vitamin A activity of the food, acceptability of taste, cost, availability, status and prestige, familiarity, seasonality, and size of the commonly eaten portion. This review has shown that there are constraints in promoting commonly recommended sources of vitamin A, despite demonstrated success in some settings.

At the same time, bananas are one of the world’s most common staple foods, and several carotenoid-rich cultivars have been identified. It is stressed that there is a great need for the identification of other banana cultivars that are likely to be carotenoid-rich, based on the color of the edible portion, and that these should be analyzed for provitamin A and other carotenoids by state-of-the-art methods with high-performance liquid chromatography [104]. Ethnography is suggested to be an important research method that could be used in identifying the potential carotenoid-rich cultivars and in gathering information needed for planning food-based vitamin A deficiency-prevention strategies, including data on factors such as production, consumption, and acceptability. Efforts should be focused on those areas of the world where bananas are an accepted staple food. Studies are needed to determine the impact that carotenoid-rich cultivars will have on improving vitamin A status.

If these results are as we suggest, plans should be made for promoting the most acceptable carotenoid-rich cultivars using participatory methods and taking into account cultural beliefs and practices. It is likely that there are carotenoid-rich cultivars in some countries that could play a more important role in protecting against vitamin A deficiency and certain chronic diseases. Some success in Pohnpei with yellow-fleshed bananas (and with orange-fleshed sweet potatoes in East Africa) suggests a potentially important role for high vitamin A–content bananas and plantains, especially where these are staple foods. In conclusion, shifting from consumption of low-carotenoid banana cultivars to those richer in provitamin A carotenoids could potentially have a great impact on the elimination of vitamin A deficiency and the improvement of general health.

Acknowledgments

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Queensland Department of Primary Industries, for assistance in the classification of bananas and other helpful comments on the paper and Suzanne Sharrock, International Network for the Improvement of Banana and Plantain (INIBAP), for providing data on orange-fleshed banana cultivars. Acknowledgment is made to the University of Queensland for provision of the International Postgraduate Research Scholarship for the primary author, who collected some of the data as part of her Ph.D. research project. Acknowledgment is also made to the Task Force Sight and Life, Thrasher Research Fund, and the Centers for Disease Control and Prevention for funds provided to support the research.

References


82. Shamim AA, Ahmed KU, Costa SS, Jahan N, Dalia SA.
Involving programme participants in the evaluation and replanning of how to reach the "hard-to-reach group (HRG)." Sight and Life Newsletter 1999;3:3–8.


Abstract

A study was carried out in Orissa, India, to evaluate the impact on vitamin A status of vitamin A supplementation integrated with an immunization campaign. Data were collected from a representative sample of 1,811 children, aged 12 to 48 months, at baseline and then at 4 and 16 weeks following implementation of vitamin A supplementation. The primary outcome indicator was serum retinol. The coverage of vitamin A supplementation was 97%. There was a significant decline in the prevalence of Bitot’s spots from 2.9% to 1.9% at 4 weeks, but the prevalence increased to 3.6% by 16 weeks. Serum retinol concentrations increased between baseline and 4 weeks (from 0.62 ± 0.32 to 0.73 ± 0.23 µmol/L, p < .001) but then decreased to 0.50 ± 0.19 µmol/L at 16 weeks, which was significantly lower than at baseline (p < .001). The greatest increase in serum retinol from baseline to 4-week follow-up was among children with lowest baseline serum retinol and children with Bitot’s spots at baseline. This study demonstrates the short-term benefits of vitamin A supplementation to be significant, especially for those whose status is most compromised. At the same time, the benefit of vitamin A supplementation in this population was transient. The impact of the vitamin A could not be sustained for the full 16 weeks in the study population. This finding calls for exploration of other means to improve vitamin A status, perhaps by adjusting the vitamin A supplementation schedule with more aggressive measures to improve intake of foods rich in bioavailable vitamin A, such as small amounts of animal foods or fortified foods. The study demonstrates the feasibility of integrating vitamin A supplementation with immunization campaigns.

Key words: EPI; immunization campaigns; Orissa, India; serum retinol; vitamin A deficiency; vitamin A supplementation, xerophthalmia

Introduction

The persistence of vitamin A deficiency among preschool children in developing countries has led to the search for strategies to improve vitamin A intake and vitamin A status. Vitamin A deficiency has long been a significant public health problem in India, in part due to the low levels of bioavailable vitamin A in the traditional diet [1]. A national vitamin A deficiency control program was initiated in India in 1970, with one component being the routine provision of vitamin A supplements through the routine delivery system remains low [2–4]. In 1999, the State of Orissa decided to integrate the distribution of vitamin A supplements with the intensified pulse polio immunization (IPPI) on national immunization days, as has been done in other countries [5–7]. High-dose vitamin A was provided with the first and last rounds of IPPI on October 24, 1999 (for children 12–42 months of age), and March 26, 2000 (for children 12–48 months of age). At the request of the State Government of Orissa, the World Health Organization (WHO) assessed the safety and feasibility of linking vitamin A supplementation with national immunization days and measured the impact of this strategy [8].
A safety study was carried out on October 25 and 26, 1999, in Orissa following the administration of vitamin A with the first IPP1 round. Safety was assessed by evaluating the development of signs and symptoms of illness (fever, diarrhea, vomiting, and anterior fontanelle bulging) among 879 randomly selected preschool children within 48 hours of receiving vitamin A on national immunization days. Of the total sample, 26 children (3.0%; 95% confidence interval, 2.0%–4.2%) displayed at least one sign of illness, and there were no differences in the prevalence of symptoms of illness between those children who received vitamin A (3.0%; 95% confidence interval, 1.9%–4.6%) and those children who did not receive vitamin A (2.8%; 95% confidence interval, 1.1%–5.7%). Further stratification by age did not reveal any differences in the prevalence of side effects that may have been attributable to receipt of vitamin A. Thus, it was concluded that administration of vitamin A on national immunization days is safe, confirming evidence reported from other countries [9–11]. A second study was subsequently conducted to measure the impact of the integrated approach.

The main objectives of the impact study were to assess the extent of vitamin A deficiency in children between 12 and 48 months of age in Orissa at baseline and to measure the impact on vitamin A status of receipt of vitamin A. One of the important questions was whether receipt of a single high dose of vitamin A would lead to a significant and sustainable improvement in vitamin A status as well as a reduction in clinical and subclinical deficiency. The study also examined whether vitamin A supplementation would lead to changes in nutritional status, anemia, and morbidity.

Methods

Data were collected from children at three points in time over a six-month period. The baseline enumeration was implemented between March 1 and 7, 2000, preceding the delivery of high-dose vitamin A supplements (200,000 IU provided as a liquid in a spoon) on a national immunization day (March 26, 2000). The first follow-up enumeration was undertaken 4 weeks after the national immunization day, from April 29 to May 4, 2000. The second follow-up enumeration was conducted 16 weeks after the national immunization day, between August 1 and 8, 2000. The study was an evaluation to assess the impact of the supplementation activity in Orissa under normal operating program conditions. In the original design, a control group was identified in neighboring Andhra Pradesh, but because of differences between the two groups it was decided to present only the data for Orissa independently. There were significant differences between Orissa and Andhra Pradesh in key demographic and health parameters. Perhaps more critical was the fact that children in Andhra had been exposed to vitamin A supplementation as part of the routine health delivery system, and it was not possible to determine the interval between vitamin A receipt and enumeration for this study, thereby making comparisons with Orissa inappropriate.

A sample size of 2,100 was initially estimated to ensure adequate power to detect a reduction in the prevalence of Bitot’s spots from 3% to 1% with 95% confidence, with a design effect of 2, and allowing for a 30% dropout rate.

Demographic and socioeconomic data collection and clinical examinations were performed for all children. Anthropometric measurements were performed at baseline and at the second follow-up among two-thirds of the children who were randomly selected. In this subsample of children, information on morbidity was collected, while every fourth child had blood taken for the determination of retinol and hemoglobin (fig. 1).

Six teams were recruited for the study, each including a medical officer, anthropometrist, laboratory technician, and local auxiliary nurse worker. Bitot’s spots were assessed by clinical examination, while information on night-blindness was obtained by a questionnaire administered to the respondents of children above 24 months of age. Local terminology for night-blindness was used to facilitate reliable responses. Data for the follow-up rounds distinguished between children whose Bitot’s spots had resolved (“healed”) from earlier rounds and those whose Bitot’s spots remained (“persistent”) in subsequent rounds and those who developed Bitot’s spots (“new cases”). The distinction between new cases (incidence) and total cases (preva-
Vitamin A supplementation delivered with oral polio vaccine

Serum retinol levels at baseline for participants with and without a history of diarrhea were compared. A significant correlation ($R^2 = 0.8635$) was observed between the serum retinol levels estimated from dried blood spot (DBS) samples and venous blood samples. Bivariate analyses of serum retinol and a set of morbidity, anthropometric, and Bitot’s spots measures were performed. Differences in mean serum retinol levels from baseline to each follow-up point were compared by paired $t$-tests. All statistical significance was accepted at the 5% probability level, and 95% confidence intervals were presented where appropriate.

Results

The total sample size of children covered at baseline in the study was 2,134 (fig. 1). All children underwent clinical examinations, and 1,410 also had anthropometric measurements and morbidity recorded. In addition, 376 children underwent biochemical investigations. Of the total baseline sample, 1,811 (85%) were available and enumerated at both follow-up rounds. There were only minor differences

![FIG. 2. Correspondence between serum retinol levels estimated from dried blood spot (DBS) samples and venous blood samples: validation study](image)
in the key baseline characteristics between the children who were followed up during all three rounds of data collection and those who were enumerated only at baseline, as seen in table 1. Higher birth order and larger family size were associated with retention in the study. The literacy rate was slightly higher among mothers of children who were not followed up than among mothers of children who were followed up. There were no differences in the other key outcome parameters, including vitamin A status, morbidity, and nutritional status.

Baseline characteristics of anemia, morbidity, growth, and vitamin A deficiency

The prevalence of low serum retinol (< 0.70 µmol/L) was 63.8% (95% confidence interval, 58.4%–69.0%), which is more than three times higher than the cutoff point recommended by WHO to indicate a severe public health problem [17]. The prevalence of severe vitamin A deficiency (serum retinol < 0.35 µmol/L) was 20.4% (95% confidence interval, 16.3%–25.1%), and the mean serum retinol level was 0.62 ± 0.32 µmol/L. The prevalence of Bitot’s spots at baseline was 2.9% (95% confidence interval, 2.2%–3.7%) (table 2).

Anemia was highly prevalent at baseline; more than two-thirds of the children had low hemoglobin levels (< 11.0 g/dl), and the mean hemoglobin level was 10.27 ± 1.41 g/dl. The prevalence of current diarrhea at the time of the baseline enumeration was 4.9% (95% confidence interval, 3.8%–6.3%). Acute lower respiratory infection was observed among 1.9% (95% confidence interval, 1.2%–2.8%) of the children at baseline. Just over one-half of the children were underweight (< –2 SD weight-for-age), while stunting (< –2 SD height-for-age) was present in 44.6% of the children and wasting (< –2 SD weight-for-height) in 25.7%.

Coverage rates

Data on the coverage of vitamin A supplementation are presented in table 3. Among those children who were eligible to receive vitamin A at the time of the March 1999 vitamin A distribution (not linked to the national immunization day), 59.8% actually received vitamin A. At the time of the October 1999 distribution (as part of the national immunization day), 95.8% received a dose of vitamin A. Finally, 97% of the children were covered with vitamin A on the March 2000 national immunization day. No other vitamin A was distributed during the course of the study period.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Noncohort (n = 323)</th>
<th>Cohort (n = 1,811)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>50.2%</td>
<td>53.2%</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>49.8%</td>
<td>46.8%</td>
<td>NS</td>
</tr>
<tr>
<td>Age group (mo)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>12–24</td>
<td>24.5%</td>
<td>27.4%</td>
<td>NS</td>
</tr>
<tr>
<td>24–48</td>
<td>75.5%</td>
<td>72.6%</td>
<td>NS</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Birth order ≥ 5</td>
<td>3.7%</td>
<td>7.8%</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Family size ≥ 6</td>
<td>32.5%</td>
<td>41.0%</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Kacha(^{b}) type of house</td>
<td>50.5%</td>
<td>48.9%</td>
<td>NS</td>
</tr>
<tr>
<td>Maternal literacy</td>
<td>58.2%</td>
<td>49.6%</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Ownership of at least 1 luxury item(^c)</td>
<td>13.9%</td>
<td>13.4%</td>
<td>NS</td>
</tr>
<tr>
<td>Mean (SE) wealth index(^d)</td>
<td>1.68 (0.084)</td>
<td>1.53 (0.033)</td>
<td>NS</td>
</tr>
<tr>
<td>Vitamin A deficiency status</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Night blindness (XN)</td>
<td>0.4%</td>
<td>0.5%</td>
<td>NS</td>
</tr>
<tr>
<td>Bitot’s spots</td>
<td>2.5%</td>
<td>2.9%</td>
<td>NS</td>
</tr>
<tr>
<td>Mean (SD) µmol/L serum retinol</td>
<td>0.59 (0.29)</td>
<td>0.62 (0.32)</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(^a\) Cohort members are children measured at all three rounds; noncohort members are children measured at only one or two rounds.

\(^b\) A kacha house is one that has a mud wall and a thatched or tiled roof.

\(^c\) A luxury item is defined as a telephone, automobile, or tractor.

\(^d\) The wealth index is calculated by scoring one point each if the household had electricity, a radio, television, and a bicycle, and then adding the points together.
Changes in morbidity, growth, and vitamin A deficiency over the study period

Table 4 outlines changes in Bitot’s spots over the course of the study period. The prevalence of Bitot’s spots at the time of the baseline examination was 2.9% (95% confidence interval, 2.15%–3.75%); the prevalence declined at the 4-week follow-up to 1.9% (95% confidence interval, 1.35%–2.68%) and then increased to 3.6% (95% confidence interval, 2.78%–4.55%) by the 16-week follow-up. The changes between the 4-week and 16-week follow-up were statistically significant. At the 4-week follow-up, the incidence (new cases) of Bitot’s spots was 0.8% (95% confidence interval, 0.46%–1.36%), and the incidence by the time of the 16-week follow-up was 3.0% (95% confidence interval, 2.25%–3.87%). Almost 62% of all cases of Bitot’s spots initially seen at baseline had resolved one month after baseline, and 68.5% of the cases seen at the 4-week follow-up (24 of the 35 cases) had healed by the time of the 16-week follow-up.

Table 5 outlines the change in major parameters over the duration of the study. The prevalence of low serum retinol (< 0.70 µmol/L) declined from 63.8% (95% confidence interval, 58.4%–69.0%) at baseline to 46.6% (95% confidence interval, 41.7%–51.4%) at the 4-week follow-up and then increased significantly.

TABLE 2. Health and nutritional status of baseline sample (cohort only)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical vitamin A deficiency</td>
<td></td>
</tr>
<tr>
<td>Night blindness [XN] (24–48 mo; n = 1,313)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Bitot’s spots (12–48 mo; n = 1,811)</td>
<td>2.9%</td>
</tr>
<tr>
<td>Serum retinol (n = 318)</td>
<td></td>
</tr>
<tr>
<td>Mean (SD) µmol/L serum retinol</td>
<td>0.62 (0.32)</td>
</tr>
<tr>
<td>&lt; 0.35</td>
<td>20.4%</td>
</tr>
<tr>
<td>0.35–0.70</td>
<td>43.4%</td>
</tr>
<tr>
<td>&lt; 0.70</td>
<td>63.8%</td>
</tr>
<tr>
<td>Anemia (n = 323)</td>
<td></td>
</tr>
<tr>
<td>Mean g/dl hemoglobin (SE)</td>
<td>10.27 (1.41)</td>
</tr>
<tr>
<td>&lt; 7</td>
<td>2.5%</td>
</tr>
<tr>
<td>7–10.9</td>
<td>65.0%</td>
</tr>
<tr>
<td>&lt; 11</td>
<td>67.5%</td>
</tr>
<tr>
<td>Diarrhea (n = 1,174)</td>
<td></td>
</tr>
<tr>
<td>Past 2 wk</td>
<td>12.9%</td>
</tr>
<tr>
<td>Current (past 24 h)</td>
<td>4.9%</td>
</tr>
<tr>
<td>Duration of current diarrhea (days)</td>
<td></td>
</tr>
<tr>
<td>1–7</td>
<td>4.5%</td>
</tr>
<tr>
<td>7–14</td>
<td>0.3%</td>
</tr>
<tr>
<td>&gt; 14</td>
<td>0.1%</td>
</tr>
<tr>
<td>Respiratory infection</td>
<td></td>
</tr>
<tr>
<td>Cough or difficulty breathing (past 2 wk)</td>
<td>19.6%</td>
</tr>
<tr>
<td>Cough or difficulty breathing (current)</td>
<td>8.2%</td>
</tr>
<tr>
<td>Acute lower respiratory infection (current)</td>
<td>1.9%</td>
</tr>
<tr>
<td>Nutritional status</td>
<td></td>
</tr>
<tr>
<td>Wasting (WFH &lt; –2 SD)</td>
<td>25.7%</td>
</tr>
<tr>
<td>Stunting (HFA &lt; –2 SD)</td>
<td>44.6%</td>
</tr>
<tr>
<td>Underweight (WFA &lt; –2 SD)</td>
<td>57.8%</td>
</tr>
</tbody>
</table>

a. WFH, Weight-for-height; HFA, height-for-age; WFA, weight-for-age.

Vitamin A supplementation delivered with oral polio vaccine

TABLE 3. Coverage of vitamin A supplements (cohort only)

<table>
<thead>
<tr>
<th>Month administered</th>
<th>Eligible children&lt;sup&gt;a&lt;/sup&gt;</th>
<th>% receiving vitamin A</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1999</td>
<td>1,272</td>
<td>59.8</td>
</tr>
<tr>
<td>October 1999</td>
<td>1,568</td>
<td>95.8</td>
</tr>
<tr>
<td>March 2000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1,782</td>
<td>97.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> The number of children eligible to receive the dose at each distribution round.

<sup>b</sup> Data on vitamin A coverage were not available for a total of 29 children in the March 2000 baseline round.

TABLE 4. Incidence of Bitot’s spots (follow-up rounds: cohort only, n = 1,811)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>% (95% confidence interval)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline cases</td>
<td>52</td>
<td>2.9% (2.15%–3.75%)</td>
<td></td>
</tr>
<tr>
<td>1st follow-up (4 wk)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32</td>
<td>1.9% (1.35%–2.68%)</td>
<td>61.5</td>
</tr>
<tr>
<td>Total cases</td>
<td>35</td>
<td>0.8% (0.46%–1.36%)</td>
<td></td>
</tr>
<tr>
<td>New cases</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old cases</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd follow-up (16 wk)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24</td>
<td>3.6% (2.78%–4.55%)</td>
<td>68.5</td>
</tr>
<tr>
<td>Total cases</td>
<td>65</td>
<td>3.0% (2.25%–3.87%)</td>
<td></td>
</tr>
<tr>
<td>New cases</td>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old cases</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Statistically significant difference (p < .05) between baseline and 4-week follow-up.

<sup>b</sup> Statistically significant difference (p < .05) between baseline and 16-week follow-up.

<sup>c</sup> Statistically significant difference (p < .05) between 4-week follow-up and 16-week follow-up.
to 86.4% (95% confidence interval, 82.4%–89.8%) by the 16-week follow-up. These changes all reached statistical significance. The prevalence of severe vitamin A deficiency (serum retinol < 0.35 µmol/L) was 20.4% (95% confidence interval, 16.3%–25.1%) at baseline and declined more than fourfold to 5.0% (95% confidence interval, 3.0%–7.7%) by the 4-week follow-up. The prevalence then increased to a level similar to that seen at baseline (22.4%; 95% confidence interval, 18.1%–27.1%) by the 16-week follow-up.

### TABLE 5. Trends in major outcome variables over the study period

<table>
<thead>
<tr>
<th>Variable</th>
<th>Time of measurement</th>
<th>n</th>
<th>Prevalence (%)</th>
<th>95% confidence interval</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night-blindness (age 24–48 mo)</td>
<td>Baseline</td>
<td>1,313</td>
<td>0.46</td>
<td>0.09%–0.82%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>0.08</td>
<td>0.00%–0.23%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>0.30</td>
<td>0.1%–0.60%</td>
<td></td>
</tr>
<tr>
<td>Bitot’s spots (age 12–48 mo)</td>
<td>Baseline</td>
<td>1,811</td>
<td>2.9</td>
<td>2.2%–3.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>1.9</td>
<td>1.4%–2.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>3.6</td>
<td>2.8%–4.6%</td>
<td></td>
</tr>
<tr>
<td>Serum retinol &lt; 0.70 µmol/L</td>
<td>Baseline</td>
<td>318</td>
<td>63.8</td>
<td>58.4%–69.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>46.1</td>
<td>40.8%–51.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>86.4</td>
<td>82.4%–89.8%</td>
<td></td>
</tr>
<tr>
<td>Serum retinol &lt; 0.35 µmol/L</td>
<td>Baseline</td>
<td>318</td>
<td>20.4</td>
<td>16.3%–25.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>5.0</td>
<td>3.0%–7.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>22.4</td>
<td>18.1%–27.1%</td>
<td></td>
</tr>
<tr>
<td>Anemia (hemoglobin &lt; 11 g/dl)</td>
<td>Baseline</td>
<td>323</td>
<td>67.5</td>
<td>65.2%–72.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>70.3</td>
<td>65.3%–74.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>60.9</td>
<td>55.7%–66.0%</td>
<td></td>
</tr>
<tr>
<td>Current diarrhea</td>
<td>Baseline</td>
<td>1,174</td>
<td>4.9</td>
<td>3.8%–6.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>4.3</td>
<td>3.2%–5.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>4.6</td>
<td>3.5%–6.0%</td>
<td></td>
</tr>
<tr>
<td>Current acute lower respiratory infection</td>
<td>Baseline</td>
<td>1,174</td>
<td>1.9</td>
<td>1.2%–2.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st follow-up (4 wk)</td>
<td></td>
<td>0.5</td>
<td>0.2%–1.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>0.8</td>
<td>0.4%–1.5%</td>
<td></td>
</tr>
<tr>
<td>Wasting</td>
<td>Baseline</td>
<td>1,153</td>
<td>25.7</td>
<td>23.2%–28.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>18.8</td>
<td>16.6%–21.2%</td>
<td></td>
</tr>
<tr>
<td>Stunting</td>
<td>Baseline</td>
<td>1,164</td>
<td>44.6</td>
<td>41.7%–47.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>35.4</td>
<td>32.7%–38.3%</td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>Baseline</td>
<td>1,164</td>
<td>57.8</td>
<td>55.0%–60.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2nd follow-up (16 wk)</td>
<td></td>
<td>48.5</td>
<td>45.6%–51.4%</td>
<td></td>
</tr>
</tbody>
</table>

*a. Statistically significant difference (p < .05) between baseline and 4-week follow-up.
*b. Statistically significant difference (p < .05) between baseline and 16-week follow-up.
*c. Statistically significant difference (p < .05) between 4-week follow-up and 16-week follow-up.

### TABLE 6. Changes in prevalence of Bitot’s spots over the study period, stratified according to exposure to October 1999 cyclone (cohort only)

<table>
<thead>
<tr>
<th>Time of measurement</th>
<th>Exposed to cyclone (n = 878)</th>
<th>Not exposed to cyclone (n = 933)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>5.1% (3.81%–6.74%)</td>
<td>0.8% (0.33%–1.48%)</td>
</tr>
<tr>
<td>1st follow-up (4 wk)</td>
<td>3.1% (2.08%–4.38%)</td>
<td>0.9% (0.40%–1.62%)</td>
</tr>
<tr>
<td>2nd follow-up (16 wk)</td>
<td>6.6% (5.05%–8.40%)</td>
<td>0.8% (0.33%–1.48%)</td>
</tr>
</tbody>
</table>

*a. Statistically significant difference (p < .05) between 4-week follow-up and 16-week follow-up.
There was little change in the prevalence of diarrhea over the course of the study, with levels consistently between 4.3% and 4.9%. On the other hand, there was a significant reduction in the prevalence of acute lower respiratory infections 4 weeks after baseline, from 1.9% to 0.5%, and the prevalence remained at approximately the same level at the 16-week follow-up (0.8%).

Anthropometric measurements were only collected at baseline and at the time of the second follow-up 16 weeks later. The prevalence of wasting declined significantly from 25.7% to 18.8% over the study period. There was also a significant decline in the prevalence of long-term malnutrition (i.e., underweight and stunting) over the study period.

Three districts in Orissa (Khurda, Cuttack, and Jajpur) were affected by a major cyclone 4 months preceding the baseline enumeration. As noted in table 6, the prevalence of Bitot’s spots in these districts was significantly higher (5.1%; 95% confidence interval, 3.81%–6.74%) at baseline than in those areas not affected by the cyclone (0.8%; 95% confidence interval, 0.33%–1.48%). In the cyclone-affected areas, a significant decline in the prevalence of Bitot’s spots was observed 4 weeks after the national immunization day to 3.1% (95% confidence interval, 2.08%–4.38%), whereas there was no change in the areas unaffected by the cyclone (0.9%; 95% confidence interval, 0.40%–1.62%). However, a significant rise in the prevalence of Bitot’s spots to 6.6% (95% confidence interval, 5.05%–8.40%) was seen in the affected areas at the time of the 16-week follow-up, while the prevalence in the nonaffected areas remained stable.

Changes in serum retinol

Table 7 presents data on trends in serum retinol over the course of the study period. The mean serum retinol level for all children at the time of the baseline enumeration was 0.62 ± 0.32 µmol/L; the level showed a significant improvement to 0.73 ± 0.23 µmol/L within 4 weeks, with a subsequent significant decline to 0.50 ± 0.19 µmol/L by the 16-week follow-up. Changes in serum retinol were also assessed with respect to baseline serum retinol levels to evaluate the degree of improvement among those children with severe vitamin A deficiency as compared with those with no vitamin A deficiency.

Children who had vitamin A deficiency at baseline (serum retinol < 0.70 µmol/L) showed a statistically significant improvement in serum retinol levels by the 4-week follow-up measurement (0.42 ± 0.15 µmol/L to 0.70 ± 0.23 µmol/L), which decreased again by the 16-week follow-up (to 0.46 ± 0.17 µmol/L) to levels similar to those at baseline. In contrast, the serum retinol levels among children with adequate vitamin A status at baseline (serum retinol ≥ 0.70 µmol/L) declined by the 4-week follow-up (from 0.97 ± 0.24 to
0.78 ± 0.23 µmol/L) and then fell further by the time of the 16-week follow-up (to 0.55 ± 0.20 µmol/L).

Children with Bitot's spots at baseline had extremely low baseline vitamin A status (mean serum retinol, 0.29 ± 0.11 µmol/L), which increased dramatically 4 weeks after supplementation (to 0.61 ± 0.20 µmol/L). By 16 weeks post-supplementation, the serum retinol levels of these children were still higher than baseline levels but had declined somewhat from the initial increase (mean, 0.43 ± 0.11 µmol/L). In contrast, the serum retinol levels of children who did not have Bitot's spots at baseline increased by the 4-week follow-up (from 0.62 ± 0.32 to 0.73 ± 0.23 µmol/L) and then declined to levels that were significantly lower than at baseline (to 0.50 ± 0.19 µmol/L).

Finally, the mean serum retinol level at baseline was significantly lower in the cyclone-affected districts (0.52 ± 0.29 µmol/L) than in the cyclone-unaffected region (0.72 ± 0.32 µmol/L). Both areas showed a significant rise in serum retinol levels by the first follow up, with the cyclone-affected areas increasing more. However, by the time of the 16-week follow-up, the mean serum retinol had decreased in both areas to similar levels (fig. 3).

**Vitamin A supplementation**

An additional series of analyses was conducted to evaluate the changes in the main outcome parameters between groups of children stratified on the basis of vitamin A receipt. Because of the high coverage of vitamin A in Orissa, such comparisons have limited statistical power, and it is important to control for the possible bias associated with self-selection. Nonetheless, a few notable results were observed, which may have important policy implications. There were no significant differences in the baseline characteristics of preschool-age children receiving and not receiving vitamin A.

Vitamin A supplementation had a positive impact on Bitot’s spots by the time of the 4-week follow-up (table 8), with the prevalence of Bitot’s spots among those receiving vitamin A (1.8%; 95% confidence interval, 1.2%–2.5%) being less than half that among those not receiving vitamin A (3.7%; 95% confidence interval, 0.6%–11.7%). However, by the 16-week follow-up, the positive impact was no longer evident among the children who received vitamin A, with the prevalence of Bitot’s spots virtually the same as at baseline.

There were some interesting observations with respect to morbidity as well. Again, although the numbers were low, children who received vitamin A were significantly less likely to have diarrhea by the time of the 4-week follow-up (3.9%; 95% confidence interval, 2.9%–5.1%) than were children who did not receive vitamin A (18.8%; 95% confidence interval, 8.0%–35.0%).

**Conclusions**

Vitamin A deficiency is a significant public health problem among preschool children in Orissa, as indicated by the high prevalence of Bitot’s spots and the low serum retinol levels at baseline. This was not surprising, given the chronic low intake of bioavailable vitamin A and the high burden of infectious morbidity in this population. These conditions were exacerbated by the lingering effects of a devastating cyclone that took place in Orissa four months before the study began. Further to this, a drought occurred during the later part of the study period, approximately 12 weeks following the administration of vitamin A.

The integration of vitamin A supplement distribution with national immunization days demonstrated high coverage for vitamin A on the national immunization days in October 1999 (95.8%) and March 2000 (97%). No significant differences in gender, age group, morbidity status, socioeconomic status, or clinical or biochemical markers of vitamin A deficiency were evident between those children who received and those who did not receive vitamin A before and during the
study period. Such uniformly high coverage rates reflect a distinct advantage of the delivery of vitamin A with national immunization days in this population as compared with routine programs.

The prevalence of Bitot’s spots declined from 2.8% to 1.9% in the study population at the 4-week follow-up, and then increased to 3.6% by the time of the 16-week follow-up. At the 4-week follow-up, 61.5% of the cases of Bitot’s spots seen at baseline had resolved and an incidence of only 0.8% (the percentage of children with new cases) was observed. Although no change in the recovery rate of Bitot’s spots was observed between the first and second follow-up periods (remaining at over 60%), the incidence of new cases increased significantly 16 weeks after the national immunization day to 3.0%. New cases of Bitot’s spots are clinically indistinguishable from chronically persistent Bitot’s spots that have resisted vitamin A therapy, and the only way to distinguish between the two types is by monitoring clinical changes longitudinally, as was done in the current study. Active lesions normally respond to therapy in two to five days. Past research has concluded

| Table 8. Trends in major outcome variables over the study period, stratified according to receipt of vitamin A |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variable        | Time of measurement | Vitamin A not received | Vitamin A received |
| Night-blindness (age 24–48 mo) | Baseline | 31 | 1,265 | 0.47 | 0.2%–1.0% |
| | 1st follow-up (4 wk) | n=31 | 1,265 | 0.1%–8.8% | 0.08 | 0.0%–0.4% |
| | 2nd follow-up (16 wk) | 54 | 1,265 | 0.1%–8.8% | 0.20 | 0.1%–0.6% |
| Bitot’s spots (age 12–48 mo) | Baseline | 54 | 1,728 | 2.8 | 2.1%–3.7% |
| | 1st follow-up (4 wk) | n=54 | 1,728 | 0.6%–11.7% | 1.8 | 1.2%–2.5% |
| | 2nd follow-up (16 wk) | 5,6 | 1,728 | 0.6%–11.7% | 3.4 | 2.6%–4.4% |
| Serum retinol < 0.70 µmol/L | Baseline | 10 | 299 | 63.2 | 57.6%–68.5% |
| | 1st follow-up (4 wk) | n=10 | 299 | 0.6%–11.7% | 45.3 | 39.7%–50.9% |
| | 2nd follow-up (16 wk) | 100 | 299 | 0.6%–11.7% | 85.8 | 81.6%–89.4% |
| Serum retinol < 0.35 µmol/L | Baseline | 10 | 299 | 63.2 | 57.6%–68.5% |
| | 1st follow-up (4 wk) | n=10 | 299 | 0.5%–40.3% | 4.7 | 2.7%–7.4% |
| | 2nd follow-up (16 wk) | 50.0 | 299 | 0.5%–40.3% | 21.9 | 17.0%–26.3% |
| Anemia (hemoglobin < 11 g/dl) | Baseline | 10 | 304 | 67.1 | 61.7%–72.2% |
| | 1st follow-up (4 wk) | n=10 | 304 | 0.5%–40.3% | 70.0 | 64.9%–74.8% |
| | 2nd follow-up (16 wk) | 75.0 | 304 | 0.5%–40.3% | 60.6 | 55.1%–65.8% |
| Current diarrhea | Baseline | 30 | 1,119 | 4.9 | 3.8%–6.3% |
| | 1st follow-up (4 wk) | n=30 | 1,119 | 0.6%–24.9% | 3.9 | 2.9%–5.1% |
| | 2nd follow-up (16 wk) | 18.8 | 1,119 | 0.6%–24.9% | 4.2 | 3.1%–5.5% |
| Current acute lower respiratory infection | Baseline | 30 | 1,119 | 4.9 | 3.8%–6.3% |
| | 1st follow-up (4 wk) | n=30 | 1,119 | 0.2%–15.4% | 4.2 | 3.1%–5.5% |
| | 2nd follow-up (16 wk) | 13.8 | 1,119 | 0.2%–15.4% | 4.2 | 3.1%–5.5% |
| Wasting | Baseline | 35 | 1,095 | 26.2 | 23.7%–28.9% |
| | 1st follow-up (4 wk) | n=35 | 1,095 | 0.2%–14.5% | 0.4 | 0.2%–1.0% |
| | 2nd follow-up (16 wk) | 14.3 | 1,095 | 0.2%–14.5% | 0.8 | 0.4%–1.5% |
| Stunting | Baseline | 35 | 1,105 | 44.0 | 41.1%–47.0% |
| | 1st follow-up (4 wk) | n=35 | 1,105 | 0.3%–75.1% | 34.8 | 32.0%–37.7% |
| | 2nd follow-up (16 wk) | 60.0 | 1,105 | 0.3%–75.1% | 45.5 | 32.0%–37.7% |
| Underweight | Baseline | 35 | 1,105 | 57.3 | 54.4%–60.2% |
| | 1st follow-up (4 wk) | n=35 | 1,105 | 5.0%–82.2% | 47.9 | 44.9%–50.9% |
| | 2nd follow-up (16 wk) | 68.6 | 1,105 | 5.0%–82.2% | 66.7 | 49.5%–81.1% |
that Bitot’s spots that do not respond to high doses of vitamin A represent sequelae of past deficiency rather than current vitamin A deficiency. The period of time before conjunctival lesions become unresponsive to vitamin A treatment has not yet been determined, and children have been found to wax and wane in and out of a vitamin A deficiency state.

There was a significant improvement in the serum retinol levels between baseline and the 4-week follow-up, which indicated an important short-term improvement in vitamin A status. However, a subsequent decline in serum retinol between the 4-week and 16-week follow-ups revealed problems in sustaining the improvements in vitamin A status over a 16-week period in this population. This finding is consistent with earlier studies in India and Indonesia that noted transient effects of high doses of vitamin A [18, 19].

A foundation of adequate dietary intake of vitamin A is essential for the periodic high-dose vitamin A supplement to build and sustain hepatic vitamin A stores. The present study provides evidence that among children with very low baseline vitamin A status and stores, the high-dose vitamin A supplements, as currently recommended by WHO, were insufficient to maintain serum retinol levels beyond 12 to 16 weeks in children. It has been suggested that dietary intake of as little as 150 RE/day* may lengthen the period of prophylactic protection of high-doses of vitamin A [20].

An assessment of the dietary intake of vitamin A–rich foods in this population would have been useful in explaining the observed results in this study, particularly in light of the unexpected drought occurring during the study period. A significant worsening of vitamin A status prior to the time of the 16-week follow-up occurred before the onset of the monsoon season. Thus, it is likely that a seasonal effect associated with a decline in the availability of green leafy vegetables, which are the primary sources of affordable β-carotene in this population, contributed to a worsening of serum retinol levels and increased the prevalence of Bitot’s spots at that point of the study.

The coastal districts of Orissa experienced two devastating cyclones prior to the study during October and November 1999, leaving thousands of people homeless, with deteriorated food availability and an increased risk of infectious diseases. In addition to this, the interior districts of Orissa experienced severe drought during the summer months during the study period. Hence, the results of the present study need to be interpreted with these environmental considerations in mind.

Although several relief measures were launched and food supplements were provided for the victims of the October cyclones in Orissa, the intake of micronutrients, particularly β-carotene, would probably have been low for a prolonged period in these areas. Food supplements are generally prepared from cereal and pulse combinations. Although such foods contribute certain micronutrients, such as B-complex vitamins and iron, the β-carotene content of these foods is typically inadequate.

The results obtained from the cyclone and noncyclone regions were interesting. Cuttack, Khurda, and Jajpur are coastal, cyclone-affected districts, whereas Angul, Kalahandi, and Sundergarh are interior districts that were not affected by the cyclone. The prevalence of vitamin A deficiency was significantly higher in cyclone-affected districts. Nearly one-third of all children in the cyclone-affected area had serum retinol levels < 0.35 µmol/L at baseline, whereas severe vitamin A deficiency (serum retinol < 0.35 µmol/L) was noticed in only 7.2% of the children in those regions not affected by the cyclone. In a district-level survey conducted in Orissa during 1996–97 [22], the prevalence of Bitot’s spots reported for one- to five-year-old children in Cuttack, Jajpur, and Khurda was 0%, 2.7%, and 0.8%, respectively. In contrast, in the present study, 5.5% of children had Bitot’s spots in Cuttack, whereas the prevalence was 9.8% in Jajpur. In Khurda the prevalence rate was 0.3%, which was lower than the value reported in the preceding three to four years. Although these two reports are not strictly comparable because of the difference in the age groups of the samples (one to five years in the 1996–97 survey and two to five years in the present survey), the huge differences observed in Cuttack and Jajpur districts suggest a definite increase in vitamin A deficiency.

The interior districts presented a different profile of vitamin A deficiency. Angul had no cases of Bitot’s spots in either survey, whereas Sundergarh recorded a decline from 4.9% in 1996–97 to 0.6% in the present study. Kalahandi registered a slight increase from 0.5% to 1.7% in the present survey. Children from both the coastal and the interior regions were recipients of 200,000 IU of vitamin A four months prior to the study period (October 1999). However, children in the coastal districts that were affected by the cyclones probably had severe food deprivation over a long period of time, and the high prevalence of deficiency might be attributed to the extremely poor vitamin A intakes by these children over the three- to four-month period preceding the survey. In the interior districts, which

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* 1 RE = 1 µg retinol or 3.33 IU vitamin A activity from retinol. Thus, 150 RE per day would translate to 450 IU, or about 75% of the mean recommended level for vitamin A per day [21].

Two units are currently used for quantifying vitamin A activity in foods, as a result of recent research findings. Both refer to 1 µg of all-trans-retinol (vitamin A). The retinol equivalent (RE) is defined as equivalent to 6 µg of dietary all-trans-β-carotene. The more recently recommended retinol activity equivalent (RAE) is defined as equivalent to 12 µg of dietary all-trans-β-carotene. Current food-composition research may still use the 6:1 ratio, since that is what is available in food-composition tables.
did not face any such calamity between the October national immunization day and baseline enumeration, the prevalence of Bitot’s spots was < 1%, suggesting the possible positive sustained effect of the previous supplementation. These observations suggest that in populations having at least minimal intakes of dietary vitamin A, supplements may have a more sustained effect on controlling vitamin A deficiency.

During the summer season preceding the second follow-up, the interior (cyclone-unaffected) districts experienced severe drought. Food intake, and particularly vitamin A intake, are generally low in the summer because of the scarcity of green leafy vegetables, which are affordable sources of β-carotene. The low food intake could explain the negative shift in vitamin A status in both regions during the second follow-up. The added stress of drought might have contributed to the precipitation of more severe deficiency in the interior districts as compared with the coastal districts, where life started to settle following the devastation caused by cyclones.

Further analysis of the impact of vitamin A supplementation on serum retinol, taking account of baseline vitamin A status, revealed some important observations. Children with vitamin A deficiency (serum retinol < 0.70 µmol/L) at baseline had a significant improvement in their serum retinol status by the 4-week follow-up. Although their serum retinol levels declined by the second follow-up, they remained above their baseline values, suggesting that there was a more sustained response among this subgroup of children.

Improvement of vitamin A status was also evaluated in relation to baseline Bitot’s spots status. Children with Bitot’s spots at baseline were found to have extremely low serum retinol levels as compared with children without Bitot’s spots. At the 4-week follow-up, both groups of children improved their serum retinol and were not statistically different from each other, but the increase among those who had Bitot’s spots at baseline was much more dramatic. This finding is consistent with earlier studies in Indonesia, where children with xerophthalma prior to receiving vitamin A had a significant increase in serum retinol following vitamin A receipt, while children with no ocular signs of xerophthalma at baseline did not have any change in serum retinol following vitamin A administration. This pattern was seen in Indonesia with both a low dose (100,000 IU) and a high dose (200,000 IU) of vitamin A, although the higher dose led to a higher increase of serum retinol among those children with xerophthalma at baseline [23].

Vitamin A supplementation also had an impact on the prevalence of morbidity, particularly current diarrhea, in this study. The prevalence of current diarrhea fell from 4.9% to 3.9% between the baseline enumeration and the 4-week follow-up among children receiving vitamin A and was about four times lower than that observed among children who had not received vitamin A. By the time of the 16-week follow-up, the prevalence of diarrhea was still significantly lower among children who received vitamin A than those who did not. These findings are somewhat different from those seen in other studies, in which vitamin A supplements had no impact on the prevalence of diarrhea, but only had an impact on the severity of infection [24, 25].

Respiratory morbidity improved from 1.9% to 0.3% by the 4-week follow-up and remained low at the time of the second follow-up. It is possible that this trend may reflect a seasonal change in morbidity due to acute respiratory infection, which was reduced much more between baseline and the 4-week follow-up among children who received vitamin A (table 8). However, these observations should be treated with caution, since the number of children not receiving vitamin A was very low.

The results of past studies have been conflicting with respect to the effects of vitamin A on morbidity among preschool-age children, although dramatic reductions in mortality have been reported. In 13 intervention studies reviewing the association between vitamin A and morbidity, vitamin A supplementation was found to have no effect on the prevalence or duration of diarrhea or respiratory infections, but only to affect their severity [26]. Six studies found no effects of vitamin A supplementation on morbidity incidence and duration, five studies found some evidence of a reduction in morbidity incidence and severity and two studies actually found an increased morbidity after vitamin A supplementation [27]. The variability in the relationship between vitamin A deficiency and morbidity in past studies may be influenced by environmental factors, including diet, access to health care, and cultural practices [28]. In the current study, the mean serum retinol levels among children with diarrhea, fever, and anemia who received vitamin A significantly increased from baseline to the 4-week follow-up.

Child growth and undernutrition are influenced by multiple factors, including dietary intake, environmental conditions, and socioeconomic status. A substantial long-term effect on physical growth would not be expected from a single micronutrient intervention such as vitamin A supplementation except in populations where vitamin A deficiency is a significant growth-limiting factor.

This study clearly demonstrates that the short-term benefits of vitamin A supplementation are significant in this population, especially for those who are most severely depleted. At the same time, it was also made clear that these benefits were temporary and limited to a period of less than 90 days at most. This finding calls for an exploration of other means of ensuring sustainable improvement in vitamin A status in similar populations, such as more frequent vitamin A supple-
mentation dosing and measures to improve the nutritive value of the general diet, as well as public health measures to improve infection control and sanitation.

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References


Anthelmintic treatment improves the hemoglobin and serum ferritin concentrations of Tanzanian schoolchildren

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Abstract

To investigate the relationships between helminth infections and iron status among school-aged children, 1,115 Tanzanian children in grades 2 through 5 were randomly assigned to treatment or control groups. The children in the treatment group were screened for infection with Schistosoma haematobium and hookworm at baseline, 3 months, and 15 months; infected children were given albendazole against hookworm and praziquantel against schistosomiasis. The control group received a placebo and did not undergo parasitological screening until 15 months after the baseline. Hematological variables were compared between the treatment and control groups. The main results were, first, that the hemoglobin concentration significantly improved after treatment for hookworm (p < .001) by 9.3 g/L in children treated for hookworm only and by 8.8 g/L in children treated for hookworm and schistosomiasis. The ferritin concentration also improved in children treated for schistosomiasis (p = .001) or hookworm (p = .019). Second, a longitudinal analysis of the data from the children in the control group showed that hookworm and schistosomiasis loads were negatively associated with hemoglobin and ferritin concentrations. Moreover, ferritin concentrations increased as C-reactive protein levels increased. Overall, the results showed that anthelmintic treatment is a useful tool for reducing anemia in areas with high hookworm and schistosomiasis endemicity. The empirical relationship between ferritin and C-reactive protein indicated that simple procedures for adjusting cutoff points for the use of ferritin as an indicator of low iron stores were unlikely to be useful in this population.

Key words: Anemia, anthelmintic treatment, ferritin, hemoglobin, iron deficiency, longitudinal data, schistosomiasis, schoolchildren, Tanzania

Introduction

Iron deficiency and iron-deficiency anemia are widely prevalent in low-income countries [1]. Iron-deficiency anemia adversely affects the physical and mental development of children [2–4] and may consequently hamper economic development [5]. In sub-Saharan Africa, helminth infections contribute significantly to the prevalence of anemia [6–8]. School-age children bear the largest burden of these diseases; there is a high prevalence of anemia (hemoglobin < 120 g/L) in schoolchildren across sub-Saharan Africa [9].

Treatment for hookworm can improve hemoglobin concentration and iron stores [10, 11], but there are mixed results regarding the effect of treatment for schistosomiasis on hemoglobin concentration [12–14] and iron stores [13]. However, observational studies [15] have demonstrated a relationship between schistosomiasis and iron stores. For both hookworm and schistosomiasis, it may be necessary to administer iron supplementation in addition to anthelmintic treatment to see an improvement in iron status [13].

The aim of the current study was to investigate further the effects of anthelmintic treatment on the iron status of school-age children; the methodology for assessing iron status was also important for the investigation. Thus far, there is no general agreement...
on the interpretation of indicators of iron stores or on the choice of indicators to define iron deficiency in populations where subclinical parasitic infections are endemic. For example, the disease environment can complicate the interpretation of ferritin as a measure of iron stores [16–18]. Some researchers have suggested that the cutoff points for ferritin should be increased in populations where C-reactive protein levels are elevated [18]. Such adjustments may be misleading in situations where, for example, ferritin increases unabatedly with increases in C-reactive protein levels. The current study aimed to investigate the relationships among children’s hemoglobin, ferritin, and C-reactive protein status by assessing the impact of treatment for hookworm and schistosomiasis on these indicator variables over a period of 15 months and by analyzing these relationships in children in the control group during the observation period.

Methods

Participants

The data were collected in Tanzania as part of a larger study to investigate the effects of anthelmintic treatment on schoolchildren’s cognitive function and educational achievement [19]. The study was conducted in 10 schools in the coastal area of Bagamoyo and Kibaha districts, and measurements were taken at baseline, 3 months, and 15 months. A school was eligible if more than 100 children were enrolled in grades 2 through 5, if it was accessible by road during the rainy season, and if it had a relatively high (> 20%) prevalence of Schistosoma haematobium, as estimated by self-report questionnaires. Children were eligible to participate in the study if they were 9 to 15 years old and were enrolled in grades 2 through 5. Children were excluded if the parent or guardian refused consent, or if the child had severe clinical symptoms of infections, physical or mental handicaps, or other chronic diseases. The study design was explained to the children and parents in Kiswahili, and the children and the parents signed a written consent form before participation. The ethics committees of the Institute of Child Health, London, the Tanzania Ministry of Health, and the Tanzania Ministry of Education and Culture approved the study design. The surveys started in May 1997, and each round lasted approximately three months. Survey round 2 commenced in September 1997 and was completed by December 1997. Survey round 3 started in October 1998 and was completed by December 1998.

A total of 2,004 children in grades 2 through 5 were eligible for participation in the study. Of these, 1,650 children returned the signed consent form and were included in the longitudinal study (fig. 1). The children were then divided into two equal groups; one group was screened for their parasitological status at the beginning of the study (treatment group), and the other was not screened until the end of the study (control group). Children were randomized to these groups after stratification according to sex and the four grade levels in the 10 schools. Following the baseline parasitology survey, children in the treatment group were selected to take further part in the study if they were either “uninfected” (< 50 eggs per gram of stool for hookworms and < 5 eggs per 10 ml of urine for schistosomiasis) or “heavily infected” (> 400 eggs per gram of stool for hookworm and/or > 50 eggs per 10 ml of urine for schistosomiasis). Children with “moderate infections” (> 50 and < 400 eggs per gram of stool for hookworm, > 5 and < 50 eggs per 10 ml of urine for schistosomiasis) took no further part in the study, partly because the broader objective of the study was to assess the impact of anthelmintic treatment on cognitive function. Hereafter, “infected” refers to “heavily infected,” as defined above. Children infected with hookworm were given 400 mg of albendazole (Smith-Kline Beecham, Brentford, UK) for three consecutive days. A single dose of praziquantel (40 mg/kg of body weight; E. Merck Pharmaceutical Division, Darmstadt, Germany) was given against schistosomiasis. The chemotherapy was repeated at survey round 2 for children in the treatment group who had become infected since survey round 1.

In survey round 3, children in the control group were also tested for hookworm, schistosomiasis, and other parasitic infections; all infected children in the control and treatment groups were treated at the end of the study. All children received three vitamin B tablets containing mixtures of 1 mg of thiamine, 1 mg of riboflavin, and 10 mg of nicotinamide in the three survey rounds; the nurses who treated the children were blinded to the nature of the tablets administered. Overall, 1,115 children entered the trial, 270 with heavy infections, 116 with no or very light infections, and 729 in the control group, whose infection status was unknown at baseline (fig. 1).

Demographic and socioeconomic variables

The child’s date of birth was recorded from the school register. Children for whom only the year of birth was known were assigned a birth date of June 15. Detailed background information was collected for the households, including the construction materials of the roof, walls, and floor. The source of drinking water, availability of toilet facilities, and number of key household possessions (bicycle, radio, refrigerator) and livestock were recorded. The information was collected through interviews with children and validated for a subsample by observation in the home and interviews with parents. An overall index of economic wealth was created by summing the scores across selected variables. The investigators designed and carried out the surveys.
Eligible children in participating schools (n=2004)

Children returning consent forms (n=1650)

Randomization

Selected for treatment group (n=849) Available at baseline (n=804)

Hookworm > 400 eggs/g stool or Schistosoma >50 eggs/10 ml urine (n=270)

Available at baseline (n=804)

Hookworm between 50 and 400 eggs/g stool and Schistosoma between 5 and 50 eggs/10 ml urine (n=418)

Selected for control group (n=801) Available at baseline (n=729)

Hookworm < 50 eggs/g stool and Schistosoma < 5 eggs/10 ml urine (n=116)

Baseline
May–August 1997

Hematology and anthropometry (n=270)

Albendazole only (n=56) Praziquantel only (n=79) Albendazole and praziquantel (n=135)

First follow up, 3 months (mean=108 days) after baseline

Hematology, anthropometry, and parasitology (n=244) Missing data (n=26)

Vitamin B only (n=183) Albendazole only (n=37) Praziquantel only (n=19) Albendazole and praziquantel (n=5)

Hematology and anthropometry (n=116)

Vitamin B only (n=116)

Second follow up, 15 months (mean=448 days) after baseline

Hematology, anthropometry, and parasitology (n=103) Missing data (n=13)

Vitamin B only (n=68) Albendazole only (n=31) Praziquantel only (n=6) Albendazole and praziquantel (n=1)

Hematology and anthropometry (n=729)

Vitamin B only (n=729)

Hematology and anthropometry (n=669) Missing data (n=60)

Missing data (n=10)

Hematology and anthropometry (n=669)

Vitamin B only (n=669)

Hematology and anthropometry (n=602) Missing data (n=127)

Missing data (n=13)

FIG. 1. Randomization of children to treatment and control groups and retention in trial
Anthropometry and hematology

The children’s weight, height, mid-upper-arm circumference, and skinfold thickness were measured in each survey round by trained observers. Electronic scales (Soehnle, Germany) were used to measure weight to the nearest 0.1 kg; the scales were intermittently checked for accuracy. The children were weighed barefoot in school uniforms. Height was measured twice with a portable stadiometer (CMS Weighing Equipment, London) with the child standing upright. If the observations differed by more than 2 mm, a third measurement was taken. The correlation between the two measurements was very high (> 0.98). Left mid-upper-arm circumference was measured to a precision of 2 mm with a waxed paper insertion tape (TALC, St. Albans, UK). Duplicate measurements of triceps skinfold thickness were taken with Holtain calipers (CMS Weighing Equipment, London).

In each survey round, the nurses drew 2 ml of blood with sterilized syringes and transferred the blood to a prelabeled tube that had a drop of EDTA to prevent clotting. A cuvette was filled immediately with blood for analysis with a portable photometer (HemoCue, Sheffield, UK). If the hemoglobin was < 80 g/L, the child’s blood was retested on the next day, and if the second value was also < 80 g/L, the child was referred to a physician. The nurses prepared a malaria thick smear, and the dried slides were placed in a box with ice packs along with the tubes containing blood. The boxes were immediately transferred to the local storage area, and the tubes containing the blood samples were centrifuged at 3,000 revolutions/min. Aliquots of 250 µl of plasma were pipetted into three separate tubes; the samples were stored in a freezer at –20°C.

The slides for malaria diagnosis were processed within three days of collection and were stained with 3% Giemsa stain, which was prepared in the laboratory by diluting 1.5 ml of Giemsa stock with 150 ml of buffered water. The slides were immersed for 45 minutes, washed and dried, and then read under an oil-immersion objective. The results were recorded as the number of parasites per 200 white blood cells. Ten fields were examined. Ferritin and C-reactive protein were measured by sandwich enzyme-linked immunosorbent assay (ELISA) using capture and horseradish peroxidase-conjugated antibodies to ferritin and C-reactive protein (Dako, Cambridge, UK). The C-reactive protein and ferritin standards were supplied by Behring Diagnostic (Milton Keynes, UK) and Dako, respectively. The substrate used was 3, 3’, 5, 5’-tetramethylbenzidine dihydrochloride (Sigma, Poole, Dorset, UK). Samples and quality controls were diluted in phosphate-buffered saline containing 0.05% Tween 20 and were run in duplicate.

Parasitology

Three urine samples were taken at each survey round from children in the treatment group on three consecutive days during school hours; the children brought stool samples to the school in a prelabeled container. For children in the control group, urine and stool analyses were performed in the third survey round. Approximately 20 ml of the urine sample was transferred to a universal tube with a pinch of Borax to stop bacterial growth without distorting the eggs. The urine and stool samples were placed in plastic bags and transported to the local laboratory for examination of parasite eggs. For S. haematobium, a 10-ml sample was filtered through a 12-mm-diameter polycarbonate membrane with a 12-µm pore size (Costar, UK). The slides were read under a microscope at low power. The number of eggs counted was expressed per 10 ml of filtered urine as an indicator of infection intensity. Two sets of observations were made, and the results were averaged to produce a more reliable estimate of egg count. A random sample of 10% of the urine samples was analyzed for accuracy by the chief technician at the laboratory.

The stool samples were examined for hookworm and other infections, such as Ascaris lumbricoides and Trichuris trichiura. For hookworm, duplicate slides containing approximately 25 mg of stool were prepared using the Kato-Katz technique [20]. A cellophane piece that had been soaked overnight in glycerol/malachite solution was placed on top of the sample. The slide was left for 7 to 10 minutes at room temperature before it was read under a microscope. Hookworm eggs were counted and expressed as eggs per gram of stool. Similarly, the number of eggs per gram of stool was estimated for other parasite species. The duplicate observations on hookworm egg counts were averaged for the data analysis.

Statistical analyses

Two lines of analysis are presented here. First, the effects of anthelmintic treatment on hemoglobin and ferritin were assessed by analyses of data from three survey rounds, performed separately for the treatment and control groups. Data from the treatment group were analyzed according to baseline infection status. Because the control group’s baseline infection status was not known, these children could not be included in one of the analyses for the treatment group. Second, a longitudinal analysis of children in the control group at the three time points was performed to estimate the relationship of schistosomiasis and hookworm egg counts to hemoglobin, ferritin, and C-reactive protein, taking into account the interrelationships among these three variables.
The first line of analysis used three-way praziquantel treatment × albendazole treatment × survey round repeated-measures analysis of variance (ANOVA) to test the null hypotheses that treatment had no effect on hemoglobin, ferritin, and C-reactive protein. A statistical software package [21] was used to compute the descriptive statistics and perform the ANOVAs. The longitudinal analysis of hemoglobin, ferritin, and C-reactive protein status for 602 children in the control group was conducted by using random-effects models [22]. Econometric methods [23] were used to estimate three models, assuming a random-effects error structure that allowed for between-children differences. The advantage of using econometric techniques was that they permitted child-specific random effects to be correlated with some of the explanatory variables in the model. For example, poor diet quality due to low income may affect children’s hemoglobin status; low income can also affect C-reactive protein levels by its effects on hygiene and sanitation. Thus, C-reactive protein was potentially correlated with the errors on the model for hemoglobin status. Standard statistical techniques do not allow such correlations and would result in inconsistent parameter estimation.

The dependent variables in the three models were hemoglobin, ferritin, and C-reactive protein concentrations. For all three models, explanatory variables included household possessions and socioeconomic status, age, height, malarial parasite count, and hookworm and schistosoma egg counts. The interdependence of hemoglobin, ferritin, and C-reactive protein status was incorporated according to the following two considerations:

First, ferritin is known to increase with C-reactive protein levels [16], although the rate of increase may vary with C-reactive protein levels. The model for ferritin included both the C-reactive protein level (CRP) and the square of the C-reactive protein level (CRP²) as explanatory variables to investigate whether ferritin increased with C-reactive protein at a decreasing or an increasing rate.

Second, hemoglobin status can be an important indicator of the ability to resist infection [24, 25]. Thus, the model for C-reactive protein included hemoglobin status as an explanatory variable.

C-reactive protein was also included as an explanatory variable in the model for hemoglobin to test for possible effects of infection on hemoglobin levels.

Results

Descriptive statistics

The sample means of selected variables for 602 children in the control group and 331 children in the treatment group with complete observations in all three survey rounds are presented in table 1. The sample means for the two groups in the first survey round were very close. The differences in the means between the two groups were statistically significant only for the number of possessions (p = .03), which was slightly higher in the treatment group.

### TABLE 1. Selected variables in three survey rounds of Tanzanian schoolchildren in the treatment and control groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control group (N = 602)</th>
<th>Treatment group (N = 331)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Round 1</td>
<td>Round 2</td>
</tr>
<tr>
<td>Age (mo)</td>
<td>146.1 ± 14.6</td>
<td>146.9 ± 15.5</td>
</tr>
<tr>
<td>Household possessionsc</td>
<td>1.36 ± 0.78</td>
<td></td>
</tr>
<tr>
<td>Socioeconomic status indexd</td>
<td>59.98 ± 11.9</td>
<td></td>
</tr>
<tr>
<td>Malaria (prevalence)</td>
<td>33%</td>
<td>51%</td>
</tr>
<tr>
<td>Malaria (merozoites/200 white blood cells)</td>
<td>28.3 ± 80.0</td>
<td></td>
</tr>
<tr>
<td>Hookworm (eggs/g stool)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Schistosomiasis (eggs/10 ml urine)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hemoglobin (g/L)</td>
<td>114.7 ± 12.6</td>
<td>112.8 ± 11.9</td>
</tr>
<tr>
<td>C-reactive protein (mg/L)</td>
<td>23.9 ± 38.2</td>
<td>20.9 ± 35.0</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td>30.8 ± 25.4</td>
<td>27.3 ± 19.8</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.37 ± 0.90</td>
<td>1.39 ± 0.90</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>31.1 ± 6.4</td>
<td>31.9 ± 8.3</td>
</tr>
</tbody>
</table>

a. Plus-minus values are means ± SD.
b. Complete data were available in all three survey rounds from these children.
c. One point each was given for ownership of a bicycle, radio, or refrigerator.
d. The socioeconomic status index was based on the quality of materials used for construction of walls, roof, and floor; the source of drinking water; and the type of fuel used.
Impact of anthelmintic treatment on hemoglobin, ferritin, and C-reactive protein

The means for the three hematological variables, hemoglobin, ferritin, and C-reactive protein, in survey rounds 1, 2, and 3 are presented in tables 2 and 3 for the treatment and control groups, respectively. In table 2, children in the treatment group were classified according to the type of treatment received. For comparison, children in the control group in table 3 were classified according to infection status in the same way as the treatment group. However, children in the control group were classified according to their infection status in survey round 3; because of ethical considerations, these were the only parasitological data taken from these children.

Table 2 shows that the baseline hemoglobin concentration was lower in infected children than in uninfected children by approximately 4 g/L for those infected only with schistosoma and by approximately 7 g/L for those infected either with hookworm alone or with both species of helminth. After treatment, the hemoglobin concentrations were at approximately the same levels in all groups. The results of ANOVA showed a significant improvement in hemoglobin after albendazole treatment ($F(1, 326) = 15.1, p < .001$). Mean Hb levels in children treated for hookworm increased by 9.3 g/L ($P < 0.001$) over the course of the study compared with an increase of only 2.7 g/L for the uninfected group. The effect of praziquantel treatment ($F(1, 326) = 1.0, p = .36$) and the interaction between albendazole treatment and praziquantel treatment ($F(1, 326) = 0.81, p = .44$) were not significant.

Anthelmintic treatment also had a significant impact on the number of children suffering from anemia (hemoglobin < 120 g/L). Before treatment, 67% (189/284) of infected children were anemic; after treatment, only 44% (118/266) were anemic. The proportions of children with more severe anemia were also reduced. The prevalence of children with hemoglobin < 110 g/L fell from 36% (102/284) to 14% (37/266); the prevalence of children with hemoglobin < 100 g/L fell from 11% (31/284) to 3% (8/284). The full distribution of hemoglobin levels in infected children before and after treatment is illustrated in figure 2.

Ferritin levels also improved after the treatment. There was a significant increase (table 2) in ferritin levels following treatment for hookworm ($albendazole \times survey \ time \ interaction: F(1, 326) = 4.0, p = .019$) and for schistosomiasis (praziquantel $\times survey \ time \ interaction: F(1, 326) = 6.7, p = .001$). There was no significant interaction between the two treatments ($albendazole \times praziquantel \times survey \ time \ interaction: F(1, 326) = 1.0, p > .36$). The analysis of C-reactive protein levels found these to be unrelated to levels of infection with hookworm or schistosoma in the treatment group ($F(1, 326) < 0.02, p > .8$ in both cases); there was no effect of either albendazole or praziquantel treatment on C-reactive protein levels ($F(1, 326) < 7.9, p > .39$ in both cases).

By contrast, the levels of the three hematological

**TABLE 2. Sample means and standard deviations of hemoglobin, C-reactive protein (CRP), and ferritin concentrations in the treatment group, classified according to baseline infection status**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uninfected (N = 116)</th>
<th>Hookworm only; albendazole only (N = 56)</th>
<th>Schistosoma haematobium only; praziquantel only (N = 79)</th>
<th>Hookworm and S. haematobium; albendazole and praziquantel (N = 135)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>119.0 ± 11.7</td>
<td>111.2 ± 16.4</td>
<td>114.4 ± 13.6</td>
<td>112.1 ± 15.2</td>
</tr>
<tr>
<td>3 mo</td>
<td>116.4 ± 10.2</td>
<td>113.6 ± 12.6</td>
<td>114.7 ± 14.5</td>
<td>115.6 ± 13.0</td>
</tr>
<tr>
<td>15 mo</td>
<td>121.7 ± 12.7</td>
<td>120.5 ± 12.6</td>
<td>119.0 ± 13.7</td>
<td>120.9 ± 11.4</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>43.2 ± 40.4</td>
<td>26.3 ± 28.1</td>
<td>30.5 ± 31.0</td>
<td>24.4 ± 17.2</td>
</tr>
<tr>
<td>3 mo</td>
<td>33.3 ± 24.3</td>
<td>23.7 ± 14.9</td>
<td>26.8 ± 18.6</td>
<td>27.4 ± 23.5</td>
</tr>
<tr>
<td>15 mo</td>
<td>32.0 ± 21.6</td>
<td>32.5 ± 22.2</td>
<td>31.1 ± 25.6</td>
<td>32.2 ± 20.6</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>2.73 ± 3.12</td>
<td>2.04 ± 3.29</td>
<td>1.92 ± 2.26</td>
<td>2.08 ± 3.13</td>
</tr>
<tr>
<td>3 mo</td>
<td>2.24 ± 3.07</td>
<td>1.67 ± 2.54</td>
<td>1.91 ± 2.81</td>
<td>2.25 ± 3.94</td>
</tr>
<tr>
<td>15 mo</td>
<td>2.22 ± 3.57</td>
<td>1.74 ± 2.40</td>
<td>1.61 ± 1.97</td>
<td>2.53 ± 3.91</td>
</tr>
</tbody>
</table>

a. "Infected" means "heavily infected" as defined in the text: > 400 eggs per gram of stool for hookworm and > 50 eggs per 10 ml of urine for schistosoma.
variables in infected, untreated children (control group; table 3) did not change over time relative to those in uninfected children. Those who were infected in survey round 3 had lower levels of hemoglobin than the uninfected children throughout the study (main effect of hookworm infection: $F(1, 448) = 13.9, p < .001$; main effect of schistosoma infection: $F(1, 448) = 4.4, p = .036$; interaction between the two infections: $F(1, 448) = 4.3, p = .039$). There was a significant improvement in hemoglobin concentration over time (main effect of survey round: $F(1, 448) = 4.12, p = .045$), but this improvement was similar in all four groups (all survey round × infection status interactions were not significant: $F(1, 448) < 1.9, p > .15$ in all cases).

The ferritin concentration in the control group, like the hemoglobin concentration, was lower in children infected with hookworm throughout the study (main effect of hookworm infection: $F(1, 448) = 32.0, p < .001$). Unlike hemoglobin, the level of ferritin did not improve in untreated children over time (main effect of survey round: $F(1, 448) = 1.64, p = .20$). Similarly, children infected with hookworm had significantly lower levels of C-reactive protein than other children ($F(1, 448) = 5.3, p = .021$); infection with schistosoma had no effect on C-reactive protein levels ($F(1, 448) = 0.14, p = .71$). C-reactive protein levels decreased over time in the control group ($F(2, 448) = 3.14, p = .044$), but this decline did not vary according to infection status (all infection × time interactions: $F(2, 448) < 1.5, p > .2$).

The effect of treatment was most apparent when the pattern over time of the hematological variables in the control and treatment groups was compared. However, it was not immediately apparent that these two groups were comparable, because parasitological classifications were made at different time points and the baseline infection status of the control group was unknown. Nevertheless, the comparison was somewhat justified by the consistency in hemoglobin, ferritin, and C-reactive protein levels of infected children across the two groups. For example, the mean hemoglobin levels of infected children were similar in the two groups at baseline (approximately 113 g/L), as were the hemoglobin levels of uninfected children in the two groups (approximately 119 g/L), suggesting that these groups had similar levels of infection. Furthermore, the relationship between infection status and hemoglobin in the control group was relatively stable over time, sug-

![Graph showing distribution of hemoglobin levels before and after treatment](image.png)

**TABLE 3.** Sample means and standard deviations of hemoglobin, C-reactive protein (CRP), and ferritin concentrations in the control group, classified according to baseline infection status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Infection status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uninfected (N = 70)</td>
</tr>
<tr>
<td>Hemoglobin (g/L)</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>119.0 ± 11.1</td>
</tr>
<tr>
<td>3 mo</td>
<td>117.7 ± 12.2</td>
</tr>
<tr>
<td>15 mo</td>
<td>120.8 ± 11.8</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>40.8 ± 34.3</td>
</tr>
<tr>
<td>3 mo</td>
<td>32.2 ± 23.7</td>
</tr>
<tr>
<td>15 mo</td>
<td>37.6 ± 28.4</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>3.20 ± 5.88</td>
</tr>
<tr>
<td>3 mo</td>
<td>2.83 ± 5.61</td>
</tr>
<tr>
<td>15 mo</td>
<td>2.60 ± 4.94</td>
</tr>
</tbody>
</table>

*a.* "Infected" means "heavily infected" as defined in the text: >400 eggs per gram of stool for hookworm and >50 eggs per 10 ml of urine for schistosoma.
gesting that the infection levels were stable.

Since *prima facie* evidence for the comparability of the two groups has been established, the results of the comparison will be examined. Treatment against hookworm improved levels of hemoglobin and ferritin in infected children; treatment against schistosomiasis improved levels of ferritin. Similarly, hemoglobin and ferritin levels in infected but untreated children did not improve over the same time period. Thus, anthelmintic treatment had a specific and beneficial effect on children’s iron status.

**Results for the longitudinal random-effects models for hemoglobin, ferritin, and C-reactive protein status of children in the control group**

Table 4 presents the results from estimating random-effects models using the data on hemoglobin, C-reactive protein, and ferritin status of 602 children in the control group. The independent and dependent variables were transformed into natural logarithms to reduce heteroscedasticity [26]. This procedure leads to estimated coefficients that are “elasticities” (percentage change in the dependent variable resulting from a 1% change in an explanatory variable). Certain hypotheses were tested using chi-square statistics.

The aim of these analyses was to investigate the relationships among hookworm, schistosomiasis, and the outcome variables (hemoglobin, C-reactive protein, and ferritin concentrations), taking into account the interdependence in the outcome variables. For the analysis of hemoglobin concentration, the elasticities of hookworm eggs per gram of stool and schistosoma eggs per 10 ml of urine were −0.006 and −0.004, respectively; both coefficients were statistically significant (p < .05). Calculations based on these coefficients imply that reducing the hookworm load by 50%, for example, would predict an increase of 1.2% in hemoglobin concentration. The negative coefficient of C-reactive protein was statistically significant.

The results for C-reactive protein levels showed that the numbers of hookworm eggs per gram of stool and schistosoma eggs per 10 ml of urine were not significantly associated with C-reactive protein status. By contrast, high levels of malaria parasites were associated with high C-reactive protein levels (p < .001). Hemoglobin status was a significant predictor of C-reactive protein with a negative coefficient, indicating that children with higher hemoglobin levels had lower C-reactive protein levels.

The model for ferritin concentration included the same explanatory variables as the models for hemoglobin and C-reactive protein but assumed a quadratic relationship between ferritin and C-reactive protein.

**TABLE 4. Longitudinal random effects model for the hemoglobin and ferritin concentration and C-reactive protein (CRP) of 602 Tanzanian schoolchildren in the control group**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Coefficient</th>
<th>SE</th>
<th>Coefficient</th>
<th>SE</th>
<th>Coefficient</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.962*</td>
<td>0.288</td>
<td>3.610*</td>
<td>1.429</td>
<td>13.060*</td>
<td>3.329</td>
</tr>
<tr>
<td>Age (mo)</td>
<td>−0.078*</td>
<td>0.046</td>
<td>−0.363*</td>
<td>0.224</td>
<td>−0.782*</td>
<td>0.432</td>
</tr>
<tr>
<td>Household possessionsb</td>
<td>0.008</td>
<td>0.006</td>
<td>0.043</td>
<td>0.028</td>
<td>−0.053</td>
<td>0.054</td>
</tr>
<tr>
<td>Socioeconomic status indexc</td>
<td>0.0006*</td>
<td>0.0003</td>
<td>0.007</td>
<td>0.002</td>
<td>0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>Malaria (merozoites/200 white blood cells)</td>
<td>0.001</td>
<td>0.003</td>
<td>−0.005</td>
<td>0.012</td>
<td>0.117*</td>
<td>0.023</td>
</tr>
<tr>
<td>Height (m)</td>
<td>0.232*</td>
<td>0.058</td>
<td>0.293</td>
<td>0.304</td>
<td>−0.338</td>
<td>0.624</td>
</tr>
<tr>
<td>Hookworm (eggs/g stool)</td>
<td>−0.006*</td>
<td>0.001</td>
<td>−0.049*</td>
<td>0.007</td>
<td>−0.022</td>
<td>0.013</td>
</tr>
<tr>
<td>Schistosomiasis (eggs/10 ml urine)</td>
<td>−0.004*</td>
<td>0.002</td>
<td>−0.005</td>
<td>0.007</td>
<td>0.009</td>
<td>0.014</td>
</tr>
<tr>
<td>Hemoglobin (g/L)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>−1.631*</td>
<td>0.447</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>−0.006*</td>
<td>0.002</td>
<td>0.158*</td>
<td>0.010</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CRP² (mg²/L²)</td>
<td>—</td>
<td>—</td>
<td>0.023*</td>
<td>0.006</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>χ², df = 3</td>
<td>1.25</td>
<td>4.72</td>
<td>7.88*</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

a. Values are slope coefficients and standard errors. The dependent and independent variables are in natural logarithms.

b. One point each was given for ownership of a bicycle, radio, or refrigerator.

c. The socioeconomic status index was based on the quality of materials used for construction of walls, roof, and floor; the source of drinking water; and the type of fuel used.

d. Chi-square test for the exogeneity of the time means of C-reactive protein in the models for hemoglobin and ferritin concentrations, and for exogeneity of time means of hemoglobin concentration in the model for C-reactive protein.

* p < .05.
The results indicated that children with higher hookworm egg counts had lower levels of ferritin. Both CRP and CRP<sup>2</sup> were estimated with positive coefficients that were statistically significant. These associations suggested that children’s ferritin concentration increased at an increasing rate with C-reactive protein levels in this population; the implications of this finding are discussed below.

**Discussion**

This paper presents an analysis of the data from a randomized school-based intervention in coastal regions of Tanzania, where hookworm and schistosomiasis infections were widely prevalent. The results showed the effectiveness of anthelmintic treatment on children’s hemoglobin and ferritin status. There were clear and independent effects of praziquantel treatment and albendazole treatment on ferritin concentration and of albendazole treatment on hemoglobin levels. This extends the results of previous studies in showing that praziquantel treatment can improve the iron status of infected schoolchildren. Further, for the design of control programs, the results indicated that children’s iron status can be increased to the level of that of uninfected controls after just two rounds of anthelmintic treatment over a course of 15 months. Given that children’s iron status is also compromised by malaria [27], and that their diets are likely to be iron deficient [28], one might expect that removal of intestinal parasites would not be sufficient for hemoglobin levels to recover without iron supplementation [13]. That hemoglobin levels recovered to the levels of those in uninfected children after two rounds of anthelmintic treatment has encouraging implications for reducing anemia in areas of high helminth endemicity. Such treatments are inexpensive and can be delivered in school health programs [29]. Of course, improving diet quality should be the long-term objective of food and nutrition policies.

The second question addressed by our study was the relationship between ferritin and C-reactive protein. The results showed that ferritin increased at an increasing rate with C-reactive protein. The implication of this result is that using ferritin alone as an indicator of iron status may provide useful information in children with low C-reactive protein concentrations but overestimate iron status in those with higher C-reactive protein concentrations. Thus, if we classify children with ferritin levels < 30 μg/L as having low iron stores [18], then of the 602 children in the control group at baseline, 217 had ferritin > 30 μg/L and would seem to have adequate iron stores. However, 108 (18%) of these children were anemic (hemoglobin < 120 g/L). By contrast, if we restricted the analysis of ferritin to the 400 children with (nonelevated) C-reactive protein < 2.2 mg/L [30], then only 7 children (1%) were anemic.

The presence of malaria parasites appeared to be a reason for the elevated C-reactive protein levels, and our study supports the conclusions of others [31] that cutoff points should be used with caution in defining iron deficiency in areas of endemic malaria infection. However, ferritin can be used more accurately as an indicator of iron status if C-reactive protein levels are taken into account. Another possibility is to disaggregate ferritin into types H and L subcomponents [32], because infections are known to differentially affect these components [33].

A final issue arising from our results concerned the methods used to investigate the relationship between iron status and helminth infections. We analyzed both longitudinal observational data and data from an intervention study. In the latter, anthelmintic treatment led to an average increase of 8.3 g/L in hemoglobin, an increase of approximately 7.3% from baseline. However, according to calculations made on the basis of estimated parameters from the longitudinal observational model, we would expect an approximately 3% increase in hemoglobin to result from this reduction in worm load. This underprediction by the longitudinal model for hemoglobin may be a result of improvements in nutrient absorption due to the reduction in parasitic loads in treated children. This emphasizes the fact that intervention studies not only investigate the relationship between variables but also can change the relationship; there is a need to use alternative methodological approaches to fully understand the interrelationships. It also suggests that cross-sectional analyses may underestimate the potential benefits of removing helminth infections.

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We gratefully acknowledge the hard work of all the staff of the MAKWAMI Project: Damaris Ngorosho, Chacha Musabi, Charles Deus, Christina Mwita, Erasto Tuntufye, Eliza Charles, Fausta Ngowi, Juliet Mduisi, Asnat Mchopa, Husna Tuli, Selemani Kungulilo, Zuhura Mfaume, Muhsin Iddi, and Gordian Rwegasira. We would also like to thank the primary school students who participated in the study, their teachers and the village leaders, and the District Education Officers, District Medical Officers, and District Health Management Teams of Bagamoyo and Kibaha districts. ELISA analysis was conducted by Vincent Assey, Michael Maganga, and Dr. Ndosi at the Tanzania Food and Nutrition Centre, Dar es Salaam. The comments of two anonymous reviewers and research support from the J.S. MacDonnell Foundation and the Research Committee of the World Bank are gratefully acknowledged.
References


Household trials with very small samples predict responses to nutrition counseling intervention

Neiva J. Valle, Iná Santos, Denise P. Gigante, Helen Gonçalves, José Martines, and Gretel H. Pelto

Abstract

Household trials were conducted to test the acceptability and feasibility of the recommendations to be delivered to the mothers in the context of a randomized intervention implemented in Pelotas, Brazil. A first home visit was paid to assess child health and feeding problems. In a second visit, the mother was encouraged to select one or two recommendations to try out over five days. The last visit was used to assess the mothers’ experiences in attempting to implement the recommendations. Nonexclusive breastfeeding, use of the bottle, monotonous diet, and low energy density of foods were the most common problems. The most frequently selected recommendations were those aiming to increase the energy density of foods. Mothers generally reported positive responses to the recommendations. The household trials highlighted the acceptability and feasibility of the planned recommendations and correctly predicted the changes that were successfully implemented by the mothers in the large intervention study.

Key words: Child feeding, dietary behavior change, dietary intervention, household trials (HHT), nutrition counseling, trials of improved practices (TIPs)

Introduction

An efficacy trial was conducted in Pelotas, Brazil, to test the nutrition component of the WHO/UNICEF strategy for Integrated Management of Childhood Illness (IMCI) [1, 2]. All 28 public health centers in the city were pair-matched according to the socio-economic status and anthropometric indicators of their catchment area populations, and they were then randomly assigned to intervention or control groups. The medical staff in the intervention group received nutrition counseling training with an IMCI-derived training course, after which samples of children who were brought by their caregivers for medical consultations were recruited in both intervention and control clinics. The trial had several purposes, including assessing the efficacy of the nutrition recommendations to improve child growth; evaluating the effectiveness of the training module to provide health workers with nutrition counseling skills; examining the feasibility of delivering the recommendations to caregivers when they bring sick children for care; and determining caregiver responses to the nutrition advice they received. The results describing the impact of the counseling intervention were previously reported [3]. It was found that children in the intervention group grew better than children who were seen by health workers who had not received the IMCI nutrition training. Although the intervention did not completely prevent the growth faltering that is ubiquitous in developing countries among children 6 to 24 months of age, the magnitude was significantly reduced among children whose caregivers received nutrition counseling in the intervention-group health centers.

The health service–based counseling intervention has several features that may contribute to its effectiveness: the quality of the nutrition advice that is given to families; the level of communication skills with which the health workers give the advice; the credibility of the health worker as a source of advice; the appropriateness of the time and place of the medical consultation for the reception of nutrition advice (i.e., this is a...
“teachable moment”); and the enhanced capacity of families to act on the advice because the recommendations are culturally and economically feasible in the local context. This paper is concerned with the last feature. Specifically, this paper describes the process that was used to adapt IMCI nutrition guidelines to local conditions in Pelotas, southern Brazil, in order to enhance their feasibility for families.

**Background**

The WHO/UNICEF IMCI strategy was developed, in part, as a means of moving away from a vertical program approach to primary health care for infants and young children. It provided an opportunity to include nutrition advice and other preventive health-care counseling within the context of care for sick children. As with the clinical components of the strategy, the content of the nutrition recommendations was derived from inputs from multiple sources of expertise in nutrition and public health. A consistent theme in expert advice, for the nutrition component as well as the other clinical components, was the need for local adaptation of the generic recommendations. Thus, the approach for establishing IMCI in health services includes an adaptation guide and extensive materials to support the adaptation process.

In the past two to three decades, the importance of local cultural, economic, and social conditions in affecting how families can respond to nutrition recommendations has become widely recognized. A major challenge for putting this recognition into practice was the lack of practical tools and techniques that would permit programs to obtain the necessary information in a timely and feasible manner. In response to that challenge, several approaches have been proposed, and some specific nutrition or nutrition-related tools have been developed [4–7].

The concept of household trials was introduced to nutrition a number of years ago by Marcia Griffiths and others in the Manoff Group [5] and has since been developed as part of a detailed qualitative approach to using formative research to test nutritional messages about complementary feeding [4]. The household trials methodology, also known as Trials of Improved Practices (TIPs), assesses the acceptability and feasibility of nutrition recommendations by consulting with mothers (or other caregivers) about their willingness to try, and their reaction to, the proposed new practices [4]. It has been used to test recommendations for programs promoting breastfeeding, complementary feeding, and increased intake of micronutrients [4, 6, 8, 9]. A version of the household trials, which was used in the current study, was developed as part of the protocol for local adaptation of the IMCI nutrition materials.

Prior to the household trials, the first part of the local adaptation study for nutrition recommendations was completed in Pelotas. This activity involved several steps, including a review of previous studies in the community, interviews with local nutrition professionals, visits to markets to determine the price of various food products, identification of feeding problems according to the child’s age (breastfeeding rates for age, and common reasons for stopping breastfeeding or for not breastfeeding exclusively) and reasons for these problems, foods commonly given, frequency of feedings, and typical amounts fed. Based on these multiple sources of input, a number of potential interventions to test in the household trials were identified. These included introduction of chicken liver, whole beans (not just broth), green leafy vegetables, and chicken and cow meat to the child’s diet; addition of oil, margarine, or butter to the child’s plate; increase in the variety of foods; and use of a cup and spoon to feed the child. Thus, the purpose of the trials was to test the feasibility and acceptability of specific foods, recipes, and food preparations, as well as generic recommendations, such as exclusive breastfeeding, increasing feeding frequency, and feeding with a cup and spoon rather than a baby bottle.

**Materials and methods**

The household trials study was conducted in a neighborhood of Pelotas that was not part of the main study. The health facility from which the sample was recruited serves a population of about 8,000, is staffed by a multiprofessional team (medical doctors, nurse, and nutritionist) who provide outpatient and maternal and child health services, and is managed by the Federal University of Pelotas. The population covered by this health facility is very similar in terms of socioeconomic and nutritional status to the population served by health services managed by the city government where the main trial was to be implemented. To find households for participation in the trial, we first reviewed the medical records of the facility to identify four children in each of the age groups under 4, 4 to 5, 6 to 11, and 12 to 17 months who had attended a consultation in the previous week.

The household trials were conducted by a team of three fieldworkers, two nutritionists, and a psychology student. The fieldworkers were trained by four of the authors: a medical doctor (I.S.), a nutritionist (D.P.G.), an epidemiologist (N.J.V.), and an anthropologist (H.G.). Their training consisted of detailed discussion of the content of the data-collection instrument and role-playing for situations that might arise in the course of the study.

Following the guidelines on the household trial study, three household visits were planned for each of the selected children. At the initial visit, the fieldworker first obtained informed consent from the mother and
then administered a short questionnaire of eight open-ended questions, asking about her child’s general health, current breastfeeding, and other feeding practices. Dietary intake data were then collected using a 24-hour dietary recall and a weekly food-frequency checklist. No counseling was given to the mother at that time, but the fieldworker made an appointment to meet with her the following day.

On the same day, at the study headquarters, a case conference was held in which the data from the interview were reviewed with the investigators (I.S., D.P.G., H.G., and N.J.V.). For each case, specific feeding problems were identified, based on the World Health Organization (WHO) guidelines.

Taking into account the socioeconomic and cultural reality of the family, as well as the availability of food in the household, the study team (fieldworker and investigator) formulated anywhere between two and nine specific recommendations for presentation to the mother. Only recommendations presumed to be relevant and feasible were made. The types of recommendations included the following: increase the frequency of breastfeeding, breastfeed exclusively, diversify the child’s diet, give meat and chicken liver, add one teaspoonful of oil or margarine to the child’s plate, give mashed bean grain instead of just the broth, increase the energy density of the food, and use a cup and spoon to feed the child.

The counseling visit was made 24 hours after the first visit. At the beginning of the visit, the fieldworker reviewed with the mother a brief summary of her current child-feeding practices. Good maternal practices were highlighted and the mother was praised. The fieldworker then tried to elicit from the mother her own perceptions about possible problems in her current practices, and if these were forthcoming she discussed potential solutions. She then went on to discuss some improvements that could be introduced to the child’s diet, based on the recommendations for the mother that had been decided at the case conference.

From the set of identified problems, the mother was asked to select which ones she would like to modify. Typically the mother wanted to try out more than one modification, although she was encouraged to focus on only one or two for the coming five-day period, after which the fieldworker would return. As a recall aid, a written reminder with the chosen recommendations was left with the mother. An appointment was made for the third visit.

The follow-up visit, which took place four to five days later, was devoted to exploring the mother’s experience in attempting to implement the recommendations she had agreed to try. In addition to discussing her experiences and perceptions, the mother was asked to give a second 24-hour recall.

Results

A total of 16 children who attended consultation at the primary health care facility were enrolled in the study. Only one child was lost between the second and the third visit, a girl 10 months old. For that child it was not possible to check compliance with and acceptability of the two recommendations made. Table 1 shows the distribution of the children according to sex, age, and current breastfeeding status. Six children were still being breastfed, and most of them were under six months of age.

Table 2 presents the feeding problems detected during the initial visit through the 24-hour dietary

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>Boys</th>
<th>Girls</th>
<th>No. breastfed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4–5</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6–11</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>12–17</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2. Distribution of the nutritional problems identified in the first household visit

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>Problem</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4 (n = 4)</td>
<td>Nonexclusive breastfeeding</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Use of bottle</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Premature weaning</td>
<td>1</td>
</tr>
<tr>
<td>4–5 (n = 4)</td>
<td>Use of bottle to give water, tea, or cow’s milk</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nonbreastfeeding*</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Low variety (monotonous diet)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nonexclusive breastfeeding</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Low energy density</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Insufficient quantity of food offered</td>
<td>1</td>
</tr>
<tr>
<td>6–11 (n = 4)</td>
<td>Low variety (monotonous diet)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Use of bottle to give water, tea, or cow’s milk</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Low energy density</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Low meal frequency</td>
<td>1</td>
</tr>
<tr>
<td>12–17 (n = 4)</td>
<td>Use of bottle to give water, tea, or cow’s milk</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Low energy density</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Insufficient quantity of food offered</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Low meal frequency</td>
<td>1</td>
</tr>
</tbody>
</table>

* Nonbreastfeeding means that the child had been completely weaned.
recall. Nonexclusive breastfeeding was a problem for three of the four children under four months of age. In one household the mother had returned to work, and the child was fully weaned off the breast and was receiving cow’s milk. The use of baby bottles to give water, tea, or cow’s milk was reported by three of the four mothers. Only two of the four children aged four to five months were still receiving maternal milk. For both of them, however, breastfeeding followed a non-exclusive pattern.

Most of the children over three months of age were given milk or liquids (fruit juices, water, or tea) by bottle. Across all age groups, the diets tended to be low in variety, consisting nearly exclusively of bean broth, rice, potatoes, pumpkin, and, eventually, only one type of meat (beef). Another problem detected in the majority of the children was the low energy density of the foods they consumed, especially as a result of the practice of giving diluted soup and only the broth when beans were cooked. Problems in the amount of food offered and low frequency of meals were also detected.

Table 3 shows the nutritional recommendations delivered at the counseling visit, according to the child’s age. Each mother received as many suggestions as necessary to alert her to problems with her feeding practices. Mothers of infants under four months of age were given advice related to breastfeeding. As expected, most of the recommendations (nearly 85%) were directed to mothers of children four months of age or older. Mothers of children under four months of age received an average of three recommendations. Mothers of older children (4 to 17 months) received an average of five recommendations.

Among mothers of the youngest children, recommendations aimed at promoting exclusive breastfeeding included advice to increase the number of breastfeedings; feeding from both breasts; stop giving tea, water, or any other milk or food; and advice on relactation. For children four or five months of age who were already receiving other foods, the recommendations consisted of beginning the intake of fruits, vegetables, and different types of animal products (chicken meat and liver, egg yolk, and dairy foods). For children six months of age and above, the recommendations were focused especially on increasing dietary diversity (changing the monotonous diet) and increasing the consumption of high-energy-density foods. Replacement of the bottle by the cup and spoon and advice to offer fruits and vegetables were the two specific recommendations most frequently delivered.

The mothers’ selections of recommendations they would try to practice for the trial are also shown in Table 3. Approximately one-third of the messages delivered were selected. Recommendations that were intended to increase the energy density of foods were the most frequently chosen (11 of 25). The second most frequently chosen group of recommendations consisted of those that were intended to change feeding methods (5 of 16). Practices aiming at breaking the monotony of the children’s diets were selected less frequently (8 of 27).

Table 3 also shows the mothers’ experiences in following up on the recommendations. At the third visit, the mothers generally reported positive reactions to the fieldworkers. Moreover, their follow-up, as assessed from both their verbal comments to the fieldworkers and the 24-hour-recall, was high. Among the mothers of children 12 months of age and older, all of the selected recommendations were followed. Among the mothers of children less than 12 months old, there were three cases in which the mother did not follow through with the recommendation after she had indicated to the fieldworker that she would be willing to give it a try. The first case was the recommendation on relactation. According to the fieldnotes of the interviewer, the mother, who had resumed full-time work outside the household, said that she had “tried to take the child with her to work, but even so the child refused to breastfeed.” The second was a recommendation to increase energy density, but the mother reported, “I read the food box and it said that type of food should not be given to small children.” In the third case, it was suggested and the mother initially agreed to try to modify her preparation of milk formula. However, at the third visit, that mother said, “I did not stop adding flour because I thought it was the best for him.”

Discussion and conclusions

To successfully address problems in child-feeding practices through nutrition counseling delivered to families at health facilities, a number of prerequisites must be met. One of these prerequisites is that the recommendations that are made by the health-care providers need to be feasible and culturally acceptable. Together with other procedures that are contained in the IMCI guidelines on adapting nutrition recommendations, household trials are an important tool for assessing acceptability and feasibility.

Because their objective is to provide feedback for program development, it is important to carry out household trials with families who are representative of the population the program is intended to serve. The household trials reported here were conducted with families who attended a primary health-care facility in a poor area of Pelotas and who displayed the types of feeding practices that have been previously shown to be typical of the population that the nutrition-counseling intervention was designed to reach. The common problems detected by other studies in Pelotas included nonexclusive breastfeeding of children less than six
Compared with an intervention in which mothers are counseled in the context of a medical consultation, the home-visiting approach used in the household trials could be considered a gold standard for assessing the feasibility of recommendations. Although the sample was very small, the indications of acceptability that emerged from the trials were borne out in the intervention study. For example, the recommendations for practices aimed at increasing the energy density of foods, which showed a high level of acceptance and follow-through in household trials, had a high level of maternal recall in the large study.

At the same time, if maternal acceptance and follow-through were low in home visits in household trials, an even lower rate of adherence would be expected during the intervention. In fact, the low acceptance of use of the cup and spoon observed during the intervention study could be foreseen from the experiences in the household trials. In the household trials, a recommendation to use the cup and spoon instead of the bottle was given a total of 14 times, but only 3 mothers agreed to try this feeding mode. This reluctance adumbrated

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>Type of recommendation</th>
<th>Suggested</th>
<th>Selected</th>
<th>Followed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>Promote breastfeeding</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Begin to breastfeed</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Stop giving tea</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Give both breasts</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>11</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>4–5</td>
<td>Promote breastfeeding</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Stop giving other foods</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Offer both breasts</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Break monotonous diet</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Give fruits or vegetables</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Give egg yolk</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Give dairy foods</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Increase energy density</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Increase the density of “papa”</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Add 1 teaspoonful of oil or margarine</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Give porridge</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Change the method of feeding</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Use cup and spoon</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Prepare fruit juice appropriately</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Increase the quantity of milk</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>23</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>Type of recommendation</th>
<th>Suggested</th>
<th>Selected</th>
<th>Followed</th>
</tr>
</thead>
<tbody>
<tr>
<td>6–11</td>
<td>Break monotonous diet</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Give fruits or vegetables</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Give egg yolk</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Give meat or liver</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Increase energy density</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Give mashed bean grain</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Give porridge</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Do not give coffee</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Change the method of feeding</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Use cup and spoon</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Prepare milk appropri- ately</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>25</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>12–17</td>
<td>Break monotonous diet</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Give fruits or vegetables</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Give meat or liver</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Increase energy density</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Give porridge</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Give the family’s food</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Add 1 teaspoonful of oil or margarine</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Change the method of feeding</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Use cup and spoon</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>22</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

**TABLE 3. Nutrition counseling recommendations and responses of mothers in the household trials**

* | a. A thick mixture of cooked and mashed vegetables with or without meat or chicken liver.
* | b. Lost follow-up in one child, in the third visit.
* | c. Number of recommendations per mother varied from 2 to 9.
* | d. Two mothers selected only one recommendation.

months of age and feeding diets that are low in energy density and variety [10–17].
the responses in the large trial, in which the suggestion was made to 12 mothers out of the 37 observed consultations, but only 3 mothers remembered having received this recommendation when they were interviewed at home, eight days after the consultation. The reasons the mothers in the household trials gave for not selecting this recommendation were that feeding with the cup and spoon was too time-consuming and that it would also waste food. The message to replace bottles with cups and spoons was kept as an intervention message in the large study because of its unequivocal relevance for preventing diarrheal diseases [18].

In the main intervention study, 57% of the recommendations given by trained doctors were focused on measures aimed at breaking the monotony of child diets. In the household trials, 27 specific recommendations were made, but only 8 were selected by mothers as something they would be willing to try. With respect to other suggestions, mothers noted the importance of giving different types of food to their children but said that because of financial constraints, they would not be able to try it, at least in the short time interval of the household trial.

The household trials showed that most of the recommendations that were included in the training materials for the health workers were acceptable to the mothers. Their initial reactions were positive, and most of the women were able to follow through with implementing the recommendations they had agreed to try. Thus, the trials were an efficient method of acquiring fundamental information to assist the researchers in planning and conducting the major community trial. Where the household trials showed that maternal choices were similar for every kind of message delivered, it could be concluded that the acceptability of the recommendations was comparable and that any constraints to the main intervention would be expected.

Apart from predicting with high precision the maternal responses to the nutritional recommendations, the results of the household trials, functioning as a pilot test of the main intervention, reassured the investigators regarding the acceptability and feasibility of the messages to be delivered. It would be desirable if all large, complex, and expensive nutritional interventions could be supported by a process that examined the feasibility and acceptability of recommendations. Together with other sources of information about the local context, household trials are an important tool in the process of designing effective nutrition interventions.

Acknowledgments

The authors are grateful to the World Health Organization, Department of Child and Adolescent Health, for funding the main intervention study. The household trials were an important step in the process of turning nutritional guidelines into suitable nutritional recommendations to the local population. The authors are also grateful to Kate Dickin, Cornell University, who played a primary role in the development of the TIPS method and its use in the IMCI Adaptation Guide and provided important information about the history of the method, as well as thoughtful advice on a draft of the paper.

References

on mothers’ decisions concerning their breastfeeding practices. MA Dissertation, Bryn Mawr College Graduate School of Arts and Sciences, Bryn Mawr, Pa, 1992.


Acceptability of community-based growth monitoring in a rural village in South Africa

Mieke Faber, Michael A. S. Phungula, Jane D. Kvalsvig, and A. J. Spinnler Benadé

Editorial commentary

A qualitative investigation of mothers’ perceptions of community-based growth monitoring activities is indeed welcome. Attitudes to and acceptability of growth monitoring are obviously key to programmatic success.

The results of this study contrast with concerns raised in the wider literature on the efficacy and cost-effectiveness of clinic-based growth monitoring (low coverage, poor attendance, favoring the younger child, poor understanding, and lack of follow-up action). In particular, three World Bank-funded nutrition projects based on growth promotion activities have come under criticism in recent months [1]. These criticisms include the inadequate attention given to the analysis of causes of malnutrition in each country, which meant that “blueprint approaches remained unchallenged.”

In contrast, the current study includes a detailed situation analysis prior to the intervention, and the aim of “creating a platform for nutrition activities” that goes beyond the usual health-related actions to include agricultural activities that directly address limited access to micronutrient-rich foods.

To make comparisons between small-scale pilot projects and large-scale operational programs may not be fair or valid, but nevertheless the current study highlights some key factors that contribute to increased acceptability. These include the detailed situation analysis, the expansion from public health actions to include the food and care-related determinants of malnutrition, and the importance of nutrition champions in the local community. In this case, the local headmaster exerted powerful influence to promote the project activities.

The report by SC UK (Save the Children UK) calls for a halt to scaling up the specific World Bank projects under review until objective reviews are complete, and an independent review of the evidence base underlying growth monitoring and promotion as well as nutrition education and supplementary feeding.

The insights gained in this study from participants remaining in the program and from those who dropped out are indeed useful. However, this work could have been usefully extended to include the views of those who had not registered in the first place. In the context of southern Africa, which includes a relatively high proportion of people living with HIV/AIDS, and where demographic profiles and family composition are changing, one wonders how the program would have specifically addressed the needs of households headed by children and older people. Studies of new approaches as described in this report are indeed welcome as a contribution to better understanding of approaches that integrate food security and health determinants of malnutrition.

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Reference

Abstract

In rural areas, a lack of infrastructure often limits the promotion and implementation of community-based nutrition activities. Growth monitoring can potentially provide a platform for the promotion and implementation of community-based nutrition activities, provided that the growth-monitoring program has a high coverage. The aim of this study was to determine the acceptability of a community-based growth-monitoring project in terms of child attendance and maternal attitude. The study was done in a mountainous rural village that lacks health facilities in KwaZulu-Natal, South Africa. Attendance registers from 1996 to 2000 were used to determine the attendance ratio, coverage, adequacy of growth monitoring, and frequency distribution of the age of participating children. In 2001, focus group discussions were used for the qualitative assessment of maternal attitudes. The community-based growth-monitoring project had an estimated coverage of 90%, at least 60% of these children were covered adequately, and attendance was equally distributed over one-year-interval age categories for children aged five years and younger. Community-based growth monitoring can therefore provide a suitable platform for the promotion and implementation of community-based nutrition activities.

Introduction

Malnutrition can be addressed through participatory, community-based nutrition programs. For these programs to be successful, an awareness of the nature, causes, and consequences of malnutrition must be created. This can be achieved by using growth monitoring as an entry point [1].

Growth monitoring is defined as the regular measuring, plotting, and interpretation of a child’s growth in order to counsel or take action when abnormal growth is detected, with the aim of improving the child’s health [2]. The role of growth monitoring can be divided into at least four broad strategies: as a screening tool, for education and promotional purposes, for nutrition surveillance, and as an integrating strategy [3].

Several countries [4–8] have moved towards a participatory approach, with the role of growth monitoring changing from a clinic-based service provided to individuals to a community-based participatory activity. The value of community-based growth monitoring lies in its ability to build confidence and instigate improvements in household practices, motivate community action, integrate and target health and nutrition services, and raise awareness of health and nutrition problems for policy advocacy [9]. Growth monitoring is an important component of several community-based nutrition and health programs, and its role varies from targeting malnourished children for nutrition rehabilitation [10] to promoting health through education [11], increasing community participation in primary health care activities [6], and mobilizing communities [7].

In South Africa, growth monitoring is included in the proposed core package of Primary Health Care (PHC) services [12], and it is a focus area of the Integrated Nutrition Programme (INP) [13] that was introduced by the Department of Health. The aim is to establish and strengthen sustainable growth-monitoring practices, first at health facilities, and second in communities.

Questions have been raised concerning the efficacy and cost-effectiveness of clinic-based growth monitoring in various countries [14–17]. Poor weighing methods, inaccurate equipment, insufficient use of growth charts, poor understanding of normal patterns of weight gain, and ignorance regarding nutritional influences affect the credibility of growth-monitoring programs [14, 17, 18]. Furthermore, a common shortcoming is that growth-monitoring information is not used for family, community, or government action [19].

A major concern regarding clinic-based growth monitoring is the selectiveness and erratic attendance of clinic participants [20]. In South Africa, studies have shown that the nutritional status of clinic attendees is not representative of the population and that clinics do not reach those in greatest need [21, 22]. Furthermore, clinic data favor the younger child [21, 23]. For example, in the Alexander Clinic, children aged 2 years and older were seldom weighed, and 68% of the child visits were by children 12 months of age or younger [21]. The high dropout rate at clinic-based growth-monitoring programs is not unique to South Africa [24]. Low coverage is not uncommon in community-based programs, either. For example, in Bangladesh, the low coverage of a growth-monitoring program carried out by the Bangladesh Rural Advancement Committee (BRAC) was seen as a major failure [25].

Maternal satisfaction with project activities is a good indicator to be used in program evaluations [2]. The benefits of growth monitoring, as perceived by mothers, include the opportunity for mothers to discuss questions about child care [17] and be reassured about the health of their children [2]. Some communities view growth monitoring as a reflection of their pride in their future generations [26]. These perceived benefits are not easily measured, but they may be evaluated by examining maternal satisfaction with the services.

The aims of this study were to measure the acceptability of a community-based growth-monitoring project in terms of attendance with regard to coverage, attendance ratio, age distribution of children attending the growth-monitoring sessions, and adequacy of growth monitoring in terms of the INP Strategy for South Africa [13]; and to determine maternal
attitude with regard to the mothers’ opinions on what they had learned, aspects either liked or disliked, the way in which the project was run, perceived health benefits, and whether they thought the project was sustainable.

Methods

Study population

The study population resided in Ndunakazi, a mountainous rural village in KwaZulu-Natal Province, South Africa. The village is approximately 11 km long and 1 km wide, with an estimated population of 1,500 people (200 households) and an estimated population density of 141/km².

In 1994, the Ndunakazi community requested the Medical Research Council (MRC) of South Africa to assist them in addressing the nutritional needs of the children in the area. The Ndunakazi Primary Health Care Committee (NPHCC) was established to facilitate communication between the MRC and the community. A situation analysis conducted by the MRC showed that the prevalence of stunting doubled from the first to the second year of life (from 10.6% to 19.8%), and that a third of the mothers had lost a child before the age of five years, mostly during infancy [27]. It could be argued that some of these infant deaths could have been prevented if the child had been growth-monitored regularly from an early age, since weight is a sensitive indicator of small changes in nutritional and health status [28]. However, only 3% of infants were taken to the clinic specifically for growth monitoring. Most children were growth-monitored on immunization dates only, a service provided by mobile clinics that were scheduled to service the area once a month. This service was, however, irregular, and many mothers had to walk long distances to reach the service point. Attending the nearest clinic, which was 18 km away, was difficult because of the poor condition of the road and the poor transport system.

During a project-planning workshop, community representatives expressed a need for the regular weighing of children “to see whether the children were healthy” and for nutrition-related activities, such as nutrition education [29]. As a result, a community-based growth-monitoring project that targeted all children from birth to the age of five years was established to supplement the services provided by the mobile clinic and nearby health facilities. The aim of the project was twofold: to create an opportunity for the mothers to have their children growth-monitored monthly, and to create a platform for nutrition activities, such as nutrition education, as well as agricultural activities.

Community-based growth-monitoring project

Growth-monitoring sessions were hosted at households that were identified by the community, taking into consideration geographical location, accessibility, the number of preschool children in the vicinity of the household, the availability of space, and the willingness of the mother of the household to participate. These home-based growth-monitoring points were called Isizinda. It was agreed that an Isizinda should serve at least 8 to 10 children in order to make it worthwhile for the nutrition monitors. Taking the size of the dwellings into consideration, the mothers suggested a maximum of 20 to 25 children per Isizinda. The Isizinda operated according to a fixed schedule, and each mother was provided with a roster. In addition, the mothers of the households hosting the Isizinda took responsibility for reminding the mothers of the next growth-monitoring date. They also took responsibility for the storage of the equipment used during the growth-monitoring sessions.

Zulu-speaking nutrition monitors were recruited by the NPHCC and employed by the MRC to perform the growth-monitoring activities. It was essential that they be able to read and write. They had to be fluent in English to enable them to communicate with the MRC project team. They were trained according to the guidelines of the World Health Organization for training health workers [30].

During the monthly growth-monitoring sessions, each child was weighed; the weight was plotted on the growth chart (which was based on a revised Road-to-Health card that was introduced in the country [31]); the growth curve was discussed with the mother; counseling was given; and if the child showed growth faltering, the child was referred to the nearest clinic (box 1). The nutrition monitors visited the children who were referred to the clinic at home to make sure that any treatment or advice given by the clinic was followed as prescribed.

Morbidity data were collected monthly from participating children during the growth-monitoring sessions. This helped the nutrition monitors to identify children with problems, and it was useful in targeting information given to the individual mothers (box 2).

The growth-monitoring sessions were used as a platform for nutrition education. The results of a situation analysis [27] were used to identify key messages. New topics were dictated by the needs of the mothers. Nutrition messages were adapted as circumstances changed. For example, when the project started, the river was the main source of drinking water, and a key message was to boil the water before drinking it. Currently, many households have access to tap water, and the relevance of this key message has decreased. Group discussions with the nutrition monitors helped to define the messages within the cultural and socioeconomic context of
the area. Simple, inexpensive educational material that was attractive and acceptable to both the mothers and the nutrition monitors was developed through discussions with the nutrition monitors, observation, and feedback from the mothers and the nutrition monitors. Nutrition and health messages were given in a group situation, as well as to mothers individually, when needed. In the group situation, active participation of the mothers was encouraged, aiming at group discussions, rather than a classroom atmosphere. The mothers were encouraged to discuss individual constraints to better nutrition and to learn from the experience of others. If a mother attended for the first time, a volunteer from the mothers who had been coming for quite some time would, under the supervision of the nutrition monitor and the other mothers present, explain the growth chart to the newcomer. Measurements taken at the Isizinda were explained and demonstrated to the newcomer.

Since 1999, the Isizinda have also served as training centers and provided the infrastructure that was needed for the promotion of the agricultural activities of a home-garden project [32] that was established to address the vitamin A deficiency prevalent in the area [27]. During the growth-monitoring sessions, the local production and daily consumption of β-carotene–rich vegetables and fruits were promoted through education regarding vitamin A nutrition, cooking of locally produced vegetables, and demonstrations of the planting process in a demonstration garden. Most of the mothers were not familiar with the β-carotene–rich crops, and the cooked vegetables were used to introduce the mothers and children to these vegetables on growth-monitoring days, teach the mothers various ways of preparation, and give the mothers the opportunity to observe their children eating and enjoying the vegetables. The latter served as motivation for the mothers to plant these vegetables at the household level and to prepare them at home.

The project was coordinated by the headmaster of the local school, assisted by the NPHCC. The nutrition monitors gave feedback on the progress of the project and discussed problems, if any, during monthly staff meetings with the project coordinator. Community meetings were held twice a year, or more often when needed. During these meetings, the community had the opportunity to raise questions and concerns regarding the project, which were then discussed and acted on according to popular vote.

The performance of the nutrition monitors and the quality of the service provided were continuously monitored by the project leader, who attended at least one growth-monitoring session every month. The project leader met monthly with the nutrition monitors to discuss the progress of the project and problems they encountered in carrying out their tasks, and to review the information collected.
Acceptability of the community-based growth-monitoring project

Attendance

Children were registered at the Isizinda when attending a growth-monitoring session for the first time, and they remained registered in the project until they started school, moved out of the area, or died. Data were obtained from the Isizinda registers from 1996 until 2000.

Attendance ratio. For each month, the numbers of children who were registered in the project and attended the growth-monitoring sessions were recorded. The attendance ratio was calculated as:

\[
\frac{\text{number of children who attended}}{\text{number of children registered}} \times 100\%
\]

The average attendance ratio for each calendar year was calculated.

Coverage. The coverage ratio is an estimate of the number of age-eligible children who were registered in the project. In 1998, all preschool children in the village were counted during a house-to-house survey. The information was used to calculate the coverage as:

\[
\frac{\text{number of children who were registered}}{\text{number of children in the village}} \times 100\%
\]

Age distribution of children attending the growth-monitoring sessions. For each calendar year, the proportion of child visits to the Isizinda per age category, in one-year intervals, was summarized.

Adequacy of growth monitoring. According to the guidelines defined by the INP Strategy, children should be growth-monitored at least five times during the first year of life, four times during the second year of life, and three times per year thereafter until the age of five years [13]. The number of times that each child who was registered in the project from the beginning until the end of the study was growth-monitored per one-year interval was compared with the INP guidelines.

Maternal attitude

Maternal attitude

In 2001, a qualitative assessment of maternal attitudes of participants and nonparticipants was performed by an independent organization (Child Development Programme of the University of Natal) using focus group discussions. It was reasoned that the mothers might find it embarrassing to voice criticisms to the project staff but be willing to speak more freely to an independent organization. Before each session, it was stressed to the mothers that the independent organization was not related in any way to the Isizinda project. It was explained to them that the purpose of the discussions was to improve the quality of the project, and they were asked to give their honest opinions about the project. Focus group discussions were conducted with four groups of participating mothers, recruited through the nine Isizinda (eight mothers per focus group), and two groups of mothers who had not been attending the growth-monitoring sessions regularly during the past year. The participants within a group were all more or less of the same age; people known to be in conflict with each other were not included in the same group; and dominating or passive people were excluded. Each focus group discussion lasted approximately one hour and was conducted by two Zulu-speaking facilitators. While one facilitator chaired the discussion, the other recorded the session and took notes. The information was later transcribed and translated.

Results

Coverage and attendance

From the establishment of the Isizinda project in August 1995 until December 2000, a total of 329 children aged five years and younger participated in the Isizinda project. Since the launch of the project (in August 1995), when 38 children attended the first growth-monitoring session, the number of children registered increased steadily, and it reached a plateau of 110 to 120 during 1997. Data collected during 1998 showed an estimated coverage of 90%.

The average monthly attendance ratio for the duration of the study was 71±10% (table 1). The frequency of child visits to the Isizinda was equally distributed over one-year-interval age categories for children younger than five years (fig. 1). Nearly two-thirds of infants and at least 70% of children one year of age and older who were registered at the Isizinda met the minimum requirements defined in the INP strategy [13] (table 2).

Maternal attitude

Maternal attitude

The results of the focus group discussions with mothers who attended the Isizinda are summarized in box 3.

<table>
<thead>
<tr>
<th>Year</th>
<th>% attending</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>79 ± 8</td>
</tr>
<tr>
<td>1997</td>
<td>65 ± 7</td>
</tr>
<tr>
<td>1998</td>
<td>69 ± 7</td>
</tr>
<tr>
<td>1999</td>
<td>69 ± 7</td>
</tr>
<tr>
<td>2000</td>
<td>77 ± 8</td>
</tr>
</tbody>
</table>
The respondents were enthusiastic about the project and were keen to have their children's weight checked regularly at the Isizinda. They were pleased that they understood the link between appropriate weight gain, nutrition, and their children's health. An important outcome was a sense of empowerment gained through a better understanding of what made their children healthy, how to check this, and skills to produce food to achieve this. The latter was accomplished by integrating the growth-monitoring activities with

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>N</th>
<th>% monitored adequately</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–&lt; 1</td>
<td>166</td>
<td>64</td>
</tr>
<tr>
<td>1–&lt; 2</td>
<td>154</td>
<td>70</td>
</tr>
<tr>
<td>2–&lt; 3</td>
<td>149</td>
<td>76</td>
</tr>
<tr>
<td>3–&lt; 4</td>
<td>146</td>
<td>81</td>
</tr>
<tr>
<td>4–&lt; 5</td>
<td>127</td>
<td>82</td>
</tr>
</tbody>
</table>

*Guidelines for minimum growth monitoring: age 0–12 months, at least five times per year; age 1–2 years, at least four times per year; age 2–5 years, at least 3 times per year [13].*
agricultural activities that promoted the local production and daily consumption of β-carotene–rich fruits and vegetables.

Overall, they were satisfied with the way in which the project was run. On the other hand, they were unhappy with the government’s mobile clinic and perceived the clinic staff as hostile and unhelpful. Prior to the Isizinda project, the mothers were not motivated to take their children to the clinic for regular growth monitoring because the rationale was never explained to them. Their experience with the staff of the mobile clinic was that the children were treated but parents were not given any information as to the nature of the problem. At the Isizinda, however, they found the nutrition monitors helpful and informative.

Some of the respondents felt that basic health care should be available at the Isizinda. Nonetheless, a reduction in mortality, better child health, and more energetic children were cited as perceived health benefits.

The mothers were keen for the Isizinda project to continue and unanimously agreed that the project should be extended to other areas. There was a desire for some kind of follow-up support, even if it was intermittent. Some mothers feared that the gains made in the community thanks to the Isizinda project would be lost if the project team left.

**Mothers not attending the Isizinda**

The respondents who either did not attend or did not attend regularly all agreed that the project had been beneficial, but for some the benefits no longer outweighed the disadvantages. Nonparticipants complained that they were too busy to attend the Isizinda. The lack of medicines at the Isizinda was seen as a disadvantage. Disputes with the owner of the household hosting the Isizinda prevented some from attending the growth-monitoring sessions.

**Discussion**

Studies in South Africa have shown that the coverage of health facility–based growth monitoring is low and biased towards the younger child [21, 23]. Clinics are often not accessible to those in greatest need [21], and clinic attendees are generally not representative of the population as a whole [21, 22]. In contrast, the Isizinda project had a high coverage and attendance ratio, and the visits to the growth-monitoring sessions were distributed almost equally over one-year-interval age categories. A benefit of the high coverage and attendance ratio is that a large number of mothers had access to the nutrition-education and agricultural training activities that were given during the growth-monitoring sessions.

The growth curve was incorporated in all education messages, thereby reinforcing the importance of regular growth monitoring. For example, when diarrhea was discussed, a deleterious effect of diarrhea was explained as a sudden weight loss, as seen on the growth curve. Since the establishment of the Isizinda project, the mothers showed a more positive attitude toward growth monitoring, probably because of a better understanding of the benefits of weighing children regularly. They appreciated the close proximity of the Isizinda to their homes, since this was convenient and saved transport costs. The Isizinda operated in households, and disputes with the owner of the household prevented some mothers from attending the growth-monitoring sessions. Should this become a major problem, venues such as neighborhood halls [33], church buildings, schools, and crèches [23] could be used.

The time available in clinics is often restricted [34], and clinic staff often do not have time to complete the growth chart [35], let alone give nutrition counseling. Nutrition education was an integral part of the activities at the Isizinda. The number of children attending the growth-monitoring sessions was relatively small (8–20 children), and sufficient time was available for nutrition education. The mothers appreciated these lessons and valued the knowledge that they gained. Most mothers could interpret the growth curve [29], and therefore they could visualize the child’s growth pattern and, as a result, appreciate the benefits of regular growth monitoring.

The nutrition monitors were seen as helpful and informative. The clinic staff had tertiary education and often westernized lifestyles, resulting in a wide gap between them and the community [36]. The nutrition monitors had some level of secondary school education and were of similar socioeconomic background as the participants. Griffiths et al. recommended that the people responsible for community-based growth monitoring should be from the community [9]. In Ndunakazi (and neighboring areas), the performance of nutrition monitors from the area was easily affected by conflict within the community, and they were not as highly respected as nutrition monitors who did not live in the area. On the other hand, nutrition monitors not living in the area were dependent on public transport, which was costly and, at times, unreliable.

Because of the small numbers, the Isizinda were not overcrowded; the mothers did not have to wait long and they could interact. This created a relaxed and sociable atmosphere. This was strengthened by the preparation of locally produced vegetables during the latter half of the study. Furthermore, the nutrition monitors reassured mothers when their children's growth curves were normal, thereby creating a positive and encouraging atmosphere. Growth monitoring in clinics is often linked to immunization, and mothers often do not appreciate the value of growth monitoring and discontinue it once the immunization schedule is
of diarrhea during the last two years of the study. This could have contributed to the decline in the prevalence of diarrhea per se on nutritional status was not measured because of the lack of a suitable control group. The small scope of the project made it difficult to measure its impact. However, behavioral changes were observed. For example, the average age of introduction of solid foods in 1995 was 2.8 ± 0.8 months [38], versus 3.6 ± 0.8 months during 1997 [39]. This could be the result of the nutrition education that addressed, among other things, infant-feeding practices. Nutrition education at the Isizinda also addressed issues regarding the causes, consequences, prevention, and treatment of diarrhea. The number of children for whom diarrhea was reported during the growth-monitoring sessions decreased steadily from 8.0% in 1996 to 2.2% in 2000 [29]. This can probably be ascribed, to some extent, to the education lessons given at the Isizinda. The installation of taps in 1999 and the improved vitamin A status resulting from the home-garden project [32] could have contributed to the decline in the prevalence of diarrhea during the last two years of the study.

The situation analysis that was done in Ndunakazi showed that 44.9% of preschool children were marginally deficient in vitamin A (serum retinol concentrations below 20 µg/dl) [27]. The regular consumption of animal products was not within their financial reach, and β-carotene–rich vegetables were not widely available within the area (personal observation). The high coverage and attendance ratio made the growth-monitoring activities an ideal platform for the promotion of the local production and daily consumption of β-carotene–rich vegetables. For a consistent supply of these vegetables, it was essential that staggered planting and cyclic production be promoted continuously. This would have been very difficult to accomplish without the platform that the growth-monitoring activities provided. The mothers attending the Isizinda had access to agricultural training and nutrition education with regard to vitamin A nutrition as part of the home-garden project. Maternal knowledge with regard to vitamin A nutrition improved significantly. Within 20 months, more than 70% of mothers could name at least three vitamin A–rich foods, they associated vitamin A–rich vegetables with the colors orange-yellow and dark green, and they could name at least one symptom related to vitamin A deficiency [32]. Dietary intake of β-carotene–rich vegetables increased, resulting in an improvement in the vitamin A intake [40] and ultimately in the vitamin A status [41] of two- to five-year-old children, with the prevalence of marginal vitamin A deficiency decreasing from 58% to 34% (p = .001). A contributing factor to the success of the home-garden project was the mothers’ understanding of the underlying factors of poor growth and health of their children, which was obtained through monthly growth monitoring and nutrition education.

In conclusion, community-based growth monitoring at home-based centers was acceptable to the mothers, and a high coverage and attendance ratio were achieved. Growth monitoring was therefore an ideal platform for the promotion of the agricultural activities of a home-garden project, which resulted in a significant improvement in child malnutrition.

Acknowledgments

We thank Pumla and Matilda for facilitating the focus group discussions; Ms. J Kelly for transcribing the data collected during the focus group discussions; our team of nutrition monitors for their invaluable support and dedication to the study; and the people of Ndunakazi Village, especially the mothers and children who participated in the study.
References

31. Road to health booklet. Observatory (Cape Town), So. Africa: Red Cross Hospital, 1995.
Dietary assessment of refugees living in camps: A case study of Mae La Camp, Thailand

Orapin Banjong, Andrea Menefee, Kitti Sranacharoenpong, Uraiporn Chittchang, Pasamai Eg-kantrong, Atitada Boonpraderm, and Sopa Tamachotipong

Abstract

This study presents data on consumption patterns, methods of food procurement, and adequacy of dietary intake among Burmese refugee camp households living along Thailand’s border with Burma. Households established for one or more years and with children under 15 years of age were sampled. A questionnaire was used to determine economic, food-consumption, and dietary intake patterns; foods consumed were weighed and measured using a 24-hour recall for the household unit; and nutritional status was determined by a Microtoise tape and digital standing scales. In total, 182 households containing 1,159 people were surveyed. The average household energy and protein intakes were 96.6% and 111.4%, respectively, of the recommended daily allowance (RDA) for healthy Thais. Twelve percent of protein was derived from animal sources. Carbohydrate, protein, and fat accounted for 84%, 9%, and 7% of total energy, respectively. The intake of vitamins A, B<sub>1</sub>, B<sub>2</sub>, and C and of calcium ranged from 24.2% to 53.1% of the RDA. Iron intake was 85.3% of the RDA, derived mainly from rice, fermented fish, mung beans, green leafy vegetables, and eggs. Ration foods supplied 60.5% to 98.18% of all nutrients consumed in the households, with the exception of vitamins A and C. Among children under five years of age, 33.7% were underweight, 36.4% were stunted, and 8.7% were wasted. Although the refugees were able to procure some nonration foods by foraging, planting trees and vegetables, raising animals, and purchasing and exchanging ration foods for other items, the quantity and quality were not sufficient to compensate for the nutrients that were low or lacking in the ration. The overwhelming majority of dietary nutrients were provided by ration foods, and although the ration and the overall diet may be adequate for short-term subsistence, they do not suffice for long-term survival and optimal growth, especially for younger children.

Key words: Burma, household consumption, nutrition status, refugees, Thailand

Background

Refugees from Burma (Myanmar), totaling nearly 140,000 people living in 10 camps along the Thailand-Burma border, receive basic food and relief assistance from the Burmese Border Consortium (BBC), as well as a variety of health and education services provided by various nongovernmental organizations. The Thai Government does not provide any type of food support for the refugee population.

Rice is the staple food for the refugees and traditionally constitutes the mainstay of the diet, which includes fermented fish and a variety of vegetables, both grown and foraged, as well as meat and fish, hunted and raised. The food basket provided by the BBC is sufficient in both quality and quantity for subsistence in short-term situations, and it has been assumed that refugees living in camps for an extended period should be able to supplement the food basket to create a balanced diet for long-term sustenance. The BBC’s basic food basket includes rice, split yellow hulled mung beans, fermented fish, soybean oil, dried chilies, and iodized salt, averaging 2,200 kcal per person per day (children under five years of age receive one-half the amount of rice, beans, and oil).
This study determined how the BBC ration foods are utilized and the ability of households to supplement their food basket, and it evaluated the nutritional status of the refugees. This study is meant to provide information to assist the BBC and other organizations involved in providing food and relief to refugees living in camps in identifying the appropriate amount and types of foods that need to be supplied in long-term refugee situations in general.

Study site

Mae La Camp, located in Mae Sot District, Tak Province, on the northern border between Thailand and Burma, has been in existence since 1995 and is home to close to 40,000 refugees. The majority of residents are members of ethnic groups from border states in Burma, mainly Skaw Karen, with some Pwo Karen, Burmese, and Mon scattered throughout. The shelters in Mae La camp are made mostly of bamboo provided by the BBC (walls and floors) and thatched roofs, with only some structural supports made of wood. Space and water are very limited within the confines of the camp.

The camp is divided into three zones and is administered by an elected camp committee. The camp is located along a main thoroughfare, and some camp residents find day labor in neighboring farms, although the movement of refugees in and out of the camp is increasingly restricted by Thai border officials. Nonetheless, the camp has a lively economy. Zone C has a large market, with over 100 small shops that sell food and goods daily. Zones A and B have a few small shops selling some dry and some fresh foods. Camp residents are free to travel between zones to access markets, health services, churches, etc.

Methods

Zone A in Mae La Camp was randomly selected as the study site from the three zones (A, B, and C). The systematic, random sampling of households in the study area included only households living in zone A for one or more years and with children under 15 years of age. The sample size was calculated as 1,079 persons \[ N \] 1,079 (total population of Mae La Camp, Burmese Border Consortium, December 2000) and \( e = 0.03 \). The average number of persons per household was six, and the calculated sample size was 180 households. An extra 10% of the households were included in the final sample; 16 households were excluded from data collection and analysis because they were not available (not at home or moved) during data collection. Data were collected during 10 days in March 2001, during the dry season, when fewer vegetables are available for foraging and water for gardens is more scarce. The refugees receive a uniform food basket throughout the year, regardless of the season.

A questionnaire was developed and implemented to collect data on household demographics, economy, and resources; sources and consumption patterns of nonration foods; and dietary intake of the household unit. The questionnaire was pretested in a small sample of households and revised for clarity and content. Data were collected during visits to the sample households by using trained interpreters to interview household members. The head of the household was interviewed on economics and food procurement. Because the refugees eat from shared plates, a 24-hour recall at the household level of food consumed during the previous day was also conducted with the household cook, including meals eaten outside of the home. The amounts of each dry ingredient consumed by the entire household, both rice and other foodstuffs, were estimated by the household member who had cooked the previous day, using real food models. Foods were weighed on a 1-g digital food balance. The amounts of food left over at the end of the previous day were estimated and weighed by using either the actual food or the food models. All household members were asked to estimate the amounts of cooked rice consumed per person per meal, and these were weighed in households that had left-over cooked rice. The age and sex of household members who had consumed the food were also recorded.

The household members were also invited to a central location for anthropometric measurements. The nutritional status of the children and adults in the sample households was evaluated by measuring their weight and height with a 100-g beam balance scale and a Microtoise tape (a metal height-measuring tape reading to the nearest 0.1 cm) to determine the level of protein–energy malnutrition. Children under age 13 were examined for clinical signs of micronutrient deficiencies, including Bitot’s spots, angular stomatitis, pallor, and goiter.

Descriptive statistics were used to analyze household demographic and economic data using SPSS 9.0. The INMUCAL New Database I (NDI), the software program used by the Institute of Nutrition at Mahidol University, Thailand, for nutrient analysis, was used to analyze the nutrient content of foods consumed from 24-hour recall [2] (trace minerals and amino acid contents of foods are not available in the database). Dietary reference intakes are currently being developed for the region, and were unavailable for use in analysis; recommended daily allowances (RDAs) were used as the reference. The RDA for each household was calculated as the sum of the individual members’ RDAs, and these data were compared with the RDAs for healthy Thais (1989) [3]. The RDA for each household was calculated as follows: the RDA for each household member who
consumed food during the 24-hour recall period was recorded; the sum of the household members’ RDA was calculated and recorded as the household RDA; and the household intake was compared with the household RDA to determine the percentage of the RDA of each nutrient that was consumed by the household.

Descriptive statistics were used to analyze average household nutrient intakes. The combined intakes of all sample households were used to calculate the proportion of nutrients from ration and nonration foods. Descriptive statistics were also used to analyze the nutritional status of children and adults. Weight for age (W/A), height for age (H/A), and weight for height (W/H) were compared with those of the World Health Organization/National Center for Health Statistics (WHO/NCHS) 1995 reference population (< –2 SD W/A, H/A, and W/H; < 80% median W/H; < 70% median W/H) [4, 5]. The adult body-mass index was calculated and compared with recognized cutoff points [6].

Results

Household demographic and economic characteristics

Data were collected from 182 of the 200 households selected for the zone A sample, with a total population of 1,159 people. Of these, 48.9% were male, 51.1% were female, and 54.1% were between the ages of 14 and 60 years (table 1). The average household size was 6.4 persons. Among the 182 households sampled, 76.9% had sought refuge in Thailand more than five years previously, and 84.1% had resided in Mae La Camp for more than two years. Eighty-six percent of the families sampled belonged to the Skaw Karen tribe. Sixty-six percent were Christian and 29.7% were Buddhist. The main occupation reported prior to coming to Thailand was agriculture (55.5%), followed by general labor (28.6%).

Food consumption

Nutrient content of overall diet

Data on food consumption were collected from 1,086 household members. The 24-hour recall interviews from 182 households revealed that the average energy intake was 96.6 ± 20.8% of the daily RDA for healthy Thais. The households consumed an average of 111.4 ± 31.1% of the RDA for total protein, but only 12% of the protein was obtained from animal sources. The intakes of vitamins A, B<sub>1</sub>, B<sub>2</sub>, and C were 36.0%, 37.8%, 24.2%, and 51.7% of the RDA, respectively (table 2). Carbohydrate, protein, and fat accounted for 84%, 9%, and 7% of the total calories, respectively.

Contribution of ration foods to nutrient intake

Ration foods (rice, beans, fermented fish, oil, and dried chili) constituted the main sources of food and provided more than 86% of all nutrients consumed in the households, except for vitamin A (38.8%), vitamin C (2.1%), vitamin B<sub>2</sub> (60.5%), and animal protein (65.4%) (table 3). Vitamins A and C were supplied mainly by nonration foods (61.2% and 97.9%, respectively) and largely from vegetables such as green gourd, pumpkin, cassava leaves, mustard leaves, morning glory, and tomato. From the ration foods, most of the energy in the diet came from rice (87.1% of total calories). Rice was also the main source of protein (71.5%), vitamin B<sub>1</sub> (64.8%), niacin (88.7%), iron (51.9%), and phosphorus (57.1%). Fermented fish and 7% of the total calories, respectively. Carbohydrate, protein, and fat accounted for 84%, 9%, and 7% of the total calories, respectively.

TABLE 1. Age and sex distribution in 182 households surveyed in Zone A, Mae La Camp<sup>a</sup>

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>1.1</td>
<td>13</td>
<td>1.3</td>
</tr>
<tr>
<td>1–5.9</td>
<td>8.5</td>
<td>99</td>
<td>9.0</td>
</tr>
<tr>
<td>6–13.9</td>
<td>11.0</td>
<td>127</td>
<td>12.3</td>
</tr>
<tr>
<td>14–60</td>
<td>26.7</td>
<td>310</td>
<td>27.4</td>
</tr>
<tr>
<td>&gt;60</td>
<td>1.6</td>
<td>18</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48.9</strong></td>
<td><strong>567</strong></td>
<td><strong>51.1</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> All percentages are based on the total sample of 1,159.
<sup>b</sup> Of the reproductive-age women interviewed, 24 were pregnant and 26 lactating.

TABLE 2. Nutrients consumed per household per day as a percentage of RDA (N = 182)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Nutrient intake/day/household (% RDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>96.6</td>
</tr>
<tr>
<td>Protein (g)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>111.4</td>
</tr>
<tr>
<td>Vitamin A (RE)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.0</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt; (mg)</td>
<td>37.8</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt; (mg)</td>
<td>24.2</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>51.7</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>63.8</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>85.3</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>53.1</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>78.2</td>
</tr>
</tbody>
</table>

<sup>a</sup> Proportion of energy supplied by carbohydrate, protein, and fat, 84:9:7; goal, 55–65:10–15:25-30.
<sup>b</sup> Proportion of animal protein to plant protein, 1:7.3 (12:88); goal, 1:1–2.
<sup>c</sup> Two units are currently used for quantifying vitamin A activity in foods, as a result of recent research findings. Both refer to 1 µg of all-trans-retinol (vitamin A). The retinol equivalent (RE) is defined as equivalent to 6 µg of dietary all-trans-β-carotene. The more recently recommended retinol activity equivalent (RAE) is defined as equivalent to 12 µg of dietary all-trans-β-carotene, and this unit is used in the INMUCAL database [2].
was the main source of calcium in the diet (82.4%), provided the fish were consumed whole and the bones eaten. The major sources of iron among ration foods were rice (51.9%), fermented fish (23.6%), and mung beans (7.1%), and among nonration foods, green leafy vegetables and eggs (13.9%).

**Weight of rice consumed per person per meal**

Most refugees (80%) ate a rice-based meal twice a day, except for children under six years old, who ate three meals per day. The amount of cooked rice consumed per person per meal was 190, 300, and 429 g for children aged 1–3, 4–6, and 7–9 years, respectively. Males aged 10–12, 13–15, 16–19, and 20 or more years consumed 506, 593, 745, and 857 g of rice per meal, respectively; females in the same age groups consumed 469, 643, 621, and 744 g, respectively (table 4).

**Nonration foods**

Nonration foods from eight identified food groups available in the camps were purchased on average one or two times per food group per month, at a cost of 5 to 6 baht per time (except for meat and fresh fish) (US$1 = approximately 40 baht). The households spent a median of about 55 baht per month on food. The median annual household income was 500 baht. The majority of households (77.5%) bought vegetables a median of four times per month, at 3 baht per month (at a cost of about 5–10 baht/kg). Most families (74.7%) obtained fresh fish at a median of twice a month at 10 baht each month (at a cost of 20–30 baht/kg). Eggs were purchased by 47.7% of households, meat by 39.0%, canned fish by 31.3%, and steamed fish by 19.8%. Most families (69.2%) bought snacks for their children (table 5).

On average, each household possessed between one-half and one square meter of land for planting. During the rainy and dry seasons (approximately from June through February), 69.8% of the households reported planting vegetables and fruits for consumption (table 6). These included one or more of the following: cassava, *Acacia concinna*, gourds, pumpkin, green peas, basil, ginger, lemongrass, banana, and/or papaya. On average, the households were able to plant one or two types of trees or other plants on their small plots of land.

## Table 3. Percentage of nutrients obtained from ration and nonration foods, all households combined ($N = 182$)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Ration foods</th>
<th>Nonration foods</th>
<th>Ration foods</th>
<th>Nonration foods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
<td>Beans</td>
<td>Fermented fish</td>
<td>Soybean oil</td>
</tr>
<tr>
<td>Energy</td>
<td>87.1</td>
<td>2.9</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>93.7</td>
<td>2.4</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>Fat</td>
<td>25.9</td>
<td>1.3</td>
<td>14.8</td>
<td>43.2</td>
</tr>
<tr>
<td>Total protein</td>
<td>71.5</td>
<td>9.8</td>
<td>8.1</td>
<td>0</td>
</tr>
<tr>
<td>Plant protein</td>
<td>81.6</td>
<td>11.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Animal protein</td>
<td>0</td>
<td>0</td>
<td>65.4</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt;</td>
<td>64.8</td>
<td>14.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt;</td>
<td>29.0</td>
<td>31.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Niacin</td>
<td>88.7</td>
<td>2.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Iron</td>
<td>51.9</td>
<td>7.1</td>
<td>23.6</td>
<td>0</td>
</tr>
<tr>
<td>Calcium</td>
<td>7.9</td>
<td>0</td>
<td>82.4</td>
<td>0</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>57.1</td>
<td>0</td>
<td>32.2</td>
<td>0</td>
</tr>
</tbody>
</table>

On average, each household possessed between one-half and one square meter of land for planting. During the rainy and dry seasons (approximately from June through February), 69.8% of the households reported planting vegetables and fruits for consumption (table 6). These included one or more of the following: cassava, *Acacia concinna*, gourds, pumpkin, green peas, basil, ginger, lemongrass, banana, and/or papaya. On average, the households were able to plant one or two types of trees or other plants on their small plots of land.

## Table 4. Quantity of cooked rice consumed according to age group

<table>
<thead>
<tr>
<th>Age (yr), sex</th>
<th>No. of persons&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Rice/person/meal Mean ± SD (g)</th>
<th>Mean no. of serving spoons or tuppees&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–3, M and F</td>
<td>43</td>
<td>190 ± 106</td>
<td>3</td>
</tr>
<tr>
<td>4–6, M and F</td>
<td>39</td>
<td>300 ± 101</td>
<td>5</td>
</tr>
<tr>
<td>7–9, M and F</td>
<td>39</td>
<td>429 ± 179</td>
<td>7</td>
</tr>
<tr>
<td>10–12, M</td>
<td>8</td>
<td>506 ± 100</td>
<td>8</td>
</tr>
<tr>
<td>10–12, F</td>
<td>17</td>
<td>469 ± 190</td>
<td>8</td>
</tr>
<tr>
<td>13–15, M</td>
<td>12</td>
<td>593 ± 140</td>
<td>10</td>
</tr>
<tr>
<td>13–15, F</td>
<td>10</td>
<td>643 ± 155</td>
<td>11</td>
</tr>
<tr>
<td>16–19, M</td>
<td>7</td>
<td>745 ± 228</td>
<td>12</td>
</tr>
<tr>
<td>16–19, F</td>
<td>7</td>
<td>621 ± 231</td>
<td>10</td>
</tr>
<tr>
<td>20–60, M&lt;sup&gt;c&lt;/sup&gt;</td>
<td>47</td>
<td>857 ± 250</td>
<td>14</td>
</tr>
<tr>
<td>20–60, F</td>
<td>54</td>
<td>744 ± 245</td>
<td>12</td>
</tr>
</tbody>
</table>

<sup>a</sup> A total of 62 households were surveyed.

<sup>b</sup> 1 tuppee = approximately 60 g of cooked rice.

<sup>c</sup> Thai Food Guide model (Nutrition Flag) recommends 8–12 tuppees/day.
land. Almost three-quarters of the households (74.2%) foraged for foods in the surrounding area, gathering bamboo shoots, mushrooms, potatoes, and wild fruits. About half of the households (55.5%) reported raising ducks, chickens, and/or pigs for consumption and sale (table 6). The households raised an average of five or six ducks and/or chickens for consumption, whereas pigs were raised in smaller numbers (approximately one pig for each household that raised them) and were more often sold than consumed.

### Nutritional status

The nutritional status measurements of 178 refugee children aged 0 to 4.9 years revealed that 33.7% were underweight (W/A < –2 SD), 36.4% were stunted (H/A < –2 SD), and 8.7% were wasted (W/H < –2 SD) (table 7). In comparison, the prevalence of malnutrition among Thai children under five years of age, reported in 1996 and based on the NCHS standard and –2 SD cutoff, was 18.6% underweight, 16.0% stunted, and 5.9% wasted [7]. Based on WHO-endorsed criteria for identifying the severity of malnutrition among children in refugee populations, children were classified as malnourished if their weight-for-height scores fell below 70% to 80% of the NCHS reference population. The prevalences of severe and moderate wasting were 0.6% and 4.1%, respectively (table 8). Among older children, 41.2% of those aged 5 to 9.9 years, 31.5% of those aged 10 to 13.9 years, and 19.7% of those aged 14 to 17.9 years were underweight (W/A < –2 SD); 61.6% of those aged 5 to 9.9 years, 51.6% of those aged 10 to 13.9 years, and 51.5% of those aged 14 to 17.9 years were stunted (H/A < –2 SD); and 1.8% of those aged 5 to 9.9 years and none of those aged 10 to 13.9 years were wasted (W/H < –2 SD) (table 7).

Among older children, 41.2% of those aged 5 to 9.9 years, 31.5% of those aged 10 to 13.9 years, and 19.7% of those aged 14 to 17.9 years were underweight (W/A < –2 SD); 61.6% of those aged 5 to 9.9 years, 51.6% of those aged 10 to 13.9 years, and 51.5% of those aged 14 to 17.9 years were stunted (H/A < –2 SD); and 1.8% of those aged 5 to 9.9 years and none of those aged 10 to 13.9 years were wasted (W/H < –2 SD) (table 7).

The nutritional status of 345 adults from the sample households was assessed using the standard body-mass index (BMI) formula and cutoffs. It was found that the majority of adults (62.6%) measured were of normal nutritional status (BMI 20–24.9), 18.8% were thin (BMI 18.5–19.9), 7.2% were very thin (BMI < 18.5), 9.6% were overweight (BMI 25–30), and 1.7% were obese (BMI > 30). All of the obese adults were female (table 9). Examinations for clinical signs of micronutrient deficiencies were conducted on 422 children. Vitamin A supplements are routinely provided to children under 6 years of age and lactating women. Among children up to 13 years of age, none had Bitot’s spots, 5.0% had active angular stomatitis wounds, 7.6% had scars from previously active wounds, 9.2% had pale eyelids, 3.6% had pale fingernails, and 0.2% had edema. Among children 7–13 years of age who were examined for goiter, 2% had grade 1 goiter (table 10).

### Discussion

Although the study results indicate that the households received sufficient quantities of energy, as compared with the RDA, the proportion of energy from carbohydrates was very high, with a proportionately small amount of energy from protein and fat. The protein intake appears more than adequate, but most of the

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**Table 5. Household expenditures on different types of food (N = 182)**

<table>
<thead>
<tr>
<th>Food</th>
<th>Households purchasing food in past month</th>
<th>Frequency of purchase (times/mo)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Amount spent (baht/month)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>n</td>
<td>Median</td>
</tr>
<tr>
<td>Meat</td>
<td>39.0</td>
<td>71</td>
<td>1</td>
</tr>
<tr>
<td>Fresh fish</td>
<td>74.7</td>
<td>136</td>
<td>2</td>
</tr>
<tr>
<td>Steamed fish</td>
<td>19.8</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Salted fish</td>
<td>9.3</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Canned fish</td>
<td>31.3</td>
<td>57</td>
<td>1</td>
</tr>
<tr>
<td>Eggs</td>
<td>47.7</td>
<td>85</td>
<td>2</td>
</tr>
<tr>
<td>Vegetables</td>
<td>77.5</td>
<td>141</td>
<td>4</td>
</tr>
<tr>
<td>Seasonal fruit</td>
<td>19.8</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Sugar</td>
<td>51.1</td>
<td>93</td>
<td>—</td>
</tr>
<tr>
<td>Snacks</td>
<td>69.2</td>
<td>126</td>
<td>—</td>
</tr>
<tr>
<td>Beverages</td>
<td>23.1</td>
<td>42</td>
<td>—</td>
</tr>
<tr>
<td>Noodles, rice noodles, ready-cooked food, other</td>
<td>13.7</td>
<td>25</td>
<td>—</td>
</tr>
</tbody>
</table>

<sup>a</sup> Frequency and amount spent are given for households purchasing that type of food; data were not collected for sugar, snacks, beverages, and noodles etc. US$1 = approximately 40 baht.

**Table 6. Households that had a garden, raised animals, or foraged for food within the previous year (N = 182)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gardening</td>
<td>69.8</td>
<td>127</td>
</tr>
<tr>
<td>Raising animals</td>
<td>55.5</td>
<td>101</td>
</tr>
<tr>
<td>Foraging</td>
<td>74.2</td>
<td>135</td>
</tr>
</tbody>
</table>
TABLE 7. Children aged 0–18 years malnourished according to the criteria weight-for-age (W/A), height-for-age (H/A), and weight-for-height (W/H) as compared with NCHS reference standard –2 SD (1983, mean ± SD)

<table>
<thead>
<tr>
<th>Criterion and age</th>
<th>Children below cutoff for W/A, H/A, and W/H (&lt; –2 SD)</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>n/N</td>
<td>%</td>
<td>n/N</td>
</tr>
<tr>
<td><strong>W/A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4.9 yr</td>
<td>33.3</td>
<td>30/90</td>
<td>34.1</td>
<td>30/88</td>
</tr>
<tr>
<td>5–9.9 yr</td>
<td>42.5</td>
<td>31/73</td>
<td>40.2</td>
<td>37/92</td>
</tr>
<tr>
<td>10–13.9 yr</td>
<td>32.0</td>
<td>16/50</td>
<td>31.0</td>
<td>13/42</td>
</tr>
<tr>
<td>14–17.9 yr</td>
<td>31.0</td>
<td>9/29</td>
<td>10.8</td>
<td>4/37</td>
</tr>
<tr>
<td><strong>H/A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4.9 yr</td>
<td>33.0</td>
<td>29/88</td>
<td>40.0</td>
<td>34/85</td>
</tr>
<tr>
<td>5–9.9 yr</td>
<td>62.2</td>
<td>46/74</td>
<td>61.1</td>
<td>55/90</td>
</tr>
<tr>
<td>10–13.9 yr</td>
<td>49.0</td>
<td>24/49</td>
<td>54.8</td>
<td>23/42</td>
</tr>
<tr>
<td>14–17.9 yr</td>
<td>51.7</td>
<td>15/29</td>
<td>51.3</td>
<td>19/37</td>
</tr>
<tr>
<td><strong>W/H</strong></td>
<td>a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4.9 yr</td>
<td>10.3</td>
<td>9/87</td>
<td>7.1</td>
<td>6/85</td>
</tr>
<tr>
<td>5–9.9 yr</td>
<td>2.7</td>
<td>2/73</td>
<td>1.1</td>
<td>1/90</td>
</tr>
<tr>
<td>10–13.9 yr</td>
<td>0</td>
<td>0/18</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14–17.9 yr</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

a. No overweight children were found using weight-for-height standard deviation from mean (W/H > 2 SD); NCHS reference was used for children up to 10.9 years only.

TABLE 8. Children aged 0 to 5 years within weight-for-height (W/H) cutoffs as compared with WHO/NCHS reference standard % median (percentage of children who fall below 70% and 80% of the median weight of children from the WHO/NCHS reference population of the same length or height)

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>No. of children</th>
<th>Severe wasting (&lt; 70% of median)</th>
<th>Moderate wasting (70%–80% of median)</th>
<th>Normal (&gt; 80% of median)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>1–1.9</td>
<td>47</td>
<td>0</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>2–4.9</td>
<td>101</td>
<td>1.0</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Total</td>
<td>172</td>
<td>0.6</td>
<td>1</td>
<td>4.1</td>
</tr>
</tbody>
</table>

TABLE 9. Adult nutrition status (age 18–60 years; N = 345) as measured by body-mass index (BMI)\(^a\)

<table>
<thead>
<tr>
<th>Sex</th>
<th>% (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very thin; BMI &lt; 18.5</td>
<td>5.0 (7)</td>
</tr>
<tr>
<td>Thin; BMI 18.5–19.9</td>
<td>26.2 (37)</td>
</tr>
<tr>
<td>Normal; BMI 20–24.9</td>
<td>63.1 (89)</td>
</tr>
<tr>
<td>Overweight; BMI 25–30</td>
<td>5.7 (8)</td>
</tr>
<tr>
<td>Obese; BMI &gt; 30</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100 (141)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th>% (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>5.0 (7)</td>
</tr>
<tr>
<td>Female</td>
<td>8.8 (18)</td>
</tr>
<tr>
<td>Total</td>
<td>7.2 (25)</td>
</tr>
<tr>
<td>Very thin; BMI &lt; 18.5</td>
<td>26.2 (37)</td>
</tr>
<tr>
<td>Thin; BMI 18.5–19.9</td>
<td>63.1 (89)</td>
</tr>
<tr>
<td>Normal; BMI 20–24.9</td>
<td>5.7 (8)</td>
</tr>
<tr>
<td>Overweight; BMI 25–30</td>
<td>0</td>
</tr>
<tr>
<td>Obese; BMI &gt; 30</td>
<td>2.9 (6)</td>
</tr>
<tr>
<td>Total</td>
<td>100 (204)</td>
</tr>
</tbody>
</table>

\(^a\) BMI = weight (kg)/height\(^2\) (cm).
protein came from plant sources, mainly from rice. Although ration foods overwhelmingly accounted for the sources of nutrients in the diet, the intakes of vitamins A, B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), and C and the mineral calcium were lower than recommended (<70% of RDA). Nonration food provided most of the vitamins A and C and heme iron, mainly because these nutrients are found in foods that were not provided in the ration.

Both children and adults consumed large quantities of rice, as compared with the recommended intakes from the Thai Food Guide [8]. When rice intake is extrapolated from more than two meals to only two meals per day, children aged four to six years would consume an average of 600 g/day, as compared with the recommended 480 g/day, and adults would consume 1,242 to 1,714 g/day, as compared with the recommended 480 to 720 g/day. The large quantities of rice consumed make it less likely that both children and adults would be able to consume adequate nutrients for optimal growth and health.

Despite the very limited space, the refugees in Mae La Camp were able to plant several types of vegetables, such as green peas and gourds, in pots or small beds. However, the limited amount of garden produce was not sufficient to fully supplement the ration, and the households had to purchase additional vegetables and other foods from shops once a week, on average. Animal food in the diet came mostly from the markets. The type of animal food eaten most often was fresh fish, but it was purchased infrequently.

Over half of the households raised chickens and/or ducks. Several animals were raised at one time; they were usually kept to produce eggs for household consumption, or the hatchlings were sold or used for religious rites. Most households were able to forage for other foods, such as bamboo shoots, mushrooms, and potatoes, and hunt birds and rodents for household consumption.

Although it was adequate in energy, as reflected in the relatively low rates of wasting, the refugee diet was disproportionately high in carbohydrates and lacked sufficient quality protein, vitamins, and minerals, as indicated by the ongoing need to provide vitamin A supplements and clinical evidence of micronutrient deficiencies. This contributed to the high prevalences of underweight and stunting among the refugee children under five years of age, which were much higher than those among Thai children under five in general. The pattern of stunting in refugee children under 18 years of age reflects the long-term insufficiency of essential nutrients necessary for optimal skeletal development and growth. The rate of stunting among children aged two to five years was two to three times higher than that among children in younger age groups (one to two years and under one year). This might be explained by the excellent rates of breastfeeding in the postpartum period; during the first year of life, the infants have a steady supply of essential nutrients, such as calcium, phosphorus, zinc, iron, essential amino acids, and essential fatty acids, from breastmilk. However, during the weaning period and into the second year of life, they receive less breastmilk and lack adequate complementary foods.

Although the rates of wasting were generally low (the WHO criteria classify wasting less than 5% as acceptable [4]), and were lower in older children (aged two to five years) than in younger children (aged one to two years) (5% vs. 19.2% W/H < –2 Z scores), this does not indicate a reversal of stunting. Instead, these children may be able to eat larger amounts of energy foods, such as rice and oil, thereby increasing their body weight relative to their height.

Conclusions

All of the households surveyed had lived in the camp for at least one year, and thus should have developed coping mechanisms with which to adequately supplement their diets. Although the refugees were able to procure some nonration foods by foraging, planting trees and vegetables, raising animals, or exchanging ration foods for other items, the quantity and quality were not sufficient to compensate for the nutrients that were low or lacking in the ration. Foods were also purchased from the markets in the camp, but the households had very weak purchasing power, as evidenced by their low monthly food expenditures.

Although energy and total protein met or exceeded the RDA, the diet was too high in carbohydrates and lacked sufficient quality protein (animal or comple-

### Table 10. Children with clinical signs and symptoms of nutrient deficiencies

<table>
<thead>
<tr>
<th>Signs and symptoms</th>
<th>% present</th>
<th>n present</th>
<th>% no data</th>
<th>n no data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitot’s spots</td>
<td>0</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Angular stomatitis</td>
<td>5.0</td>
<td>21</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Active wound</td>
<td>7.6</td>
<td>32</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dry lesion</td>
<td>9.2</td>
<td>39</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pale eyelids</td>
<td>3.6</td>
<td>15</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pale fingernails</td>
<td>0.2</td>
<td>1</td>
<td>11.1</td>
<td>47</td>
</tr>
<tr>
<td>Goiter grade 1</td>
<td>2.0</td>
<td>4</td>
<td>12.2</td>
<td>24</td>
</tr>
</tbody>
</table>

* Data for goiter are from 197 children aged 7 to 13 years who were examined for goiter sign. All children found to have goiter grade 1 were 7 to 12 years old and were from three households that migrated to Thailand in 1991, 1992, and 1993 and later moved to Mae La Camp in 1997, 1998, and 2000, respectively. Data for all other signs and symptoms are based on 422 children aged 0 to 13 years.
mentary plant protein). The intakes of vitamins A, B<sub>1</sub>, B<sub>2</sub>, and C, as well as of calcium, were low, and vitamins A and C had to be obtained predominantly from nonration foods. The diet contained few sources of calcium, especially for younger children who may not be able to chew fish bones or for those families who do not consume the bones.

The overwhelming majority of dietary nutrients were provided by ration foods, and although the ration diet and the overall diet may be adequate for short-term subsistence, they do not suffice for long-term survival and optimal growth, especially for younger children. In response, the Burmese Border Consortium is considering implementing a series of options to address the high proportion of carbohydrate and low proportion of animal protein and fat in the diet, as well as to improve the micronutrient balance in the diet. The options include implementing a comprehensive plan to support gardens and animal husbandry; fortifying or providing fortified foods in the food basket; and initiating nutrition education via existing community health workers and teachers. Similar programs being undertaken among other refugee populations should also consider these options, after having undertaken similar studies on their nutritional status, methods of procuring food, and dietary intake patterns.

References

**Abstract**

Zinc deficiency during pregnancy affects the outcome of pregnancy. A high prevalence of zinc deficiency (55.5%) has been reported among pregnant women. It is not known whether pregnancy leads to zinc deficiency due to the increased fetal needs or whether the women are zinc deficient when they become pregnant. No data are available on the zinc status of nulliparous nonpregnant women from India. To assess the magnitude of zinc deficiency among nulliparous nonpregnant women in a rural community in Haryana State, India. A community-based cross-sectional survey was conducted in six villages of a rural area in a district of Haryana State, India. All nulliparous nonpregnant women aged 18 years or over who were willing to participate in the study were enrolled. Each woman was questioned about her age, socioeconomic status, and dietary pattern with the use of a pretested semistructured questionnaire. Blood from the antecubital vein was drawn to assess the serum zinc levels using an atomic absorption spectrophotometer. Serum zinc levels less than 70.0 µg/dl were considered to indicate zinc deficiency. The dietary intakes of zinc, protein, and calories were assessed by the 24-hour dietary recall method. Two hundred eighty-eight nulliparous nonpregnant women were enrolled. Forty-one percent had zinc deficiency, and 75.7%, 1.4%, and 7.3% of the women consumed less than 50% of the recommended intake of zinc, protein, and calories, respectively. Women who consumed less than 50% of the recommended intake of calories (1,875 kcal) were at a 4.9 times higher risk of zinc deficiency than women who consumed more than 50% of the recommended intake. A high prevalence of zinc deficiency was found among the nulliparous nonpregnant women in the area studied.

**Key words:** Calorie intake, nonpregnant women, nulliparous women, zinc deficiency

**Introduction**

Zinc plays an essential role during periods of rapid growth and development. It is an important micro- nutrient during pregnancy. A recent study from India reported a 55.5% prevalence of zinc deficiency among pregnant women [1]. No data are available on the zinc status of nulliparous nonpregnant women from India, and hence the present study was conducted to assess the magnitude of zinc deficiency among this group in a rural community of Haryana State, India.

**Methods**

A community-based cross-sectional survey was conducted in six villages of a rural community of a district in Haryana State, India, from November 2000 to October 2001. All nulliparous nonpregnant women at least 18 years of age were enrolled in the study by visits to their homes. No woman declined to participate in the study. The inclusion criteria were that the women had to be married and living with their husbands and free from any known chronic illness that would affect their dietary intake. The nonpregnancy status of the subjects was confirmed by inquiring about the last menstrual period. The Ethical Committee of the All India Institute of Medical Sciences, New Delhi, approved the
study. The objectives of the study were explained to the women, and informed consent was obtained. All women participated in the study. Each woman was asked about her age, socioeconomic status (Udai Pareek Classification) [2], and dietary pattern with the use of a pretested, semistructured questionnaire.

The magnitude of zinc deficiency was assessed by measuring serum zinc levels. Blood from the antecubital vein was drawn and collected in previously labeled polypropylene tubes. The tubes were transported in ice packs to the central laboratory. The blood samples were centrifuged at 3,500 rpm at 4°C for 30 minutes, which separated the serum. The serum was collected in Eppendorf vials and stored at –80°C until analysis. The zinc level was determined by the standard atomic absorption spectrophotometric method [3]. Estimations were undertaken in batches of 50 serum samples each. Standard reference serum with a known level of zinc (Sero AS, Norway) was estimated for serum zinc level with each batch of estimation for internal quality control. All estimations were undertaken in triplicate. The mean of the three values was reported as the serum zinc level for that particular sample. For the batch of estimation, where the serum zinc level for the control was over- or underestimated, the batch of estimation was repeated. Serum samples with zinc levels less than 70 µg/dl were considered to indicate zinc deficiency [4]. Serum zinc measurement, although a good indicator of zinc status, does not itself conclusively diagnose zinc deficiency. However, serum zinc level is still considered to be a useful practical indicator to assess zinc status [5, 6].

The dietary intake of 78% of the women was assessed by using the 24-hour dietary recall method [7]. The intakes of zinc and calories were calculated by using the Nutritive Value of Indian Foods published by the Indian Council of Medical Research [8].

The data were subjected to statistical tests of the mean and standard deviation by using SPSS version 7.5. Univariate logistic regression analysis was performed, and crude relative risks and 95% confidence intervals were calculated.

Results

Two hundred eighty-eight nulliparous nonpregnant women were enrolled in the study. The mean age of the study subjects was 20.3 ± 2.3 years. The majority of the women (78.1%) were of lower-middle-class and middle-class socioeconomic status. Blood was collected from 258 women. The remaining 30 refused to have blood collected; their characteristics were similar to those of the women who consented to provide blood samples.

The mean serum zinc level of the women was 74.2 ± 23.1 µg/dl. Forty-one percent of the women had zinc deficiency (table 1). The data on dietary patterns revealed that 76% of the women were vegetarians. The daily mean dietary intakes of zinc, protein, and calories were 6.0 ± 2.3 mg, 48.6 ± 27.5 g, and 1,564.7 ± 410 kcal, respectively (table 2). It was found that 75.7%, 1.4%, and 7.3% of the women consumed less than 50% of the recommended daily intakes of zinc, protein, and calories, respectively. Univariate logistic regression analysis revealed that women consuming less than 50% of the recommended daily intake of calories (1,875 kcal) were at a 4.9 times higher risk of zinc deficiency than those consuming more than 50% of the recommended daily intake (95% confidence interval, 1.5–16.1).

Discussion

The present study revealed a high prevalence (41.5%) of zinc deficiency among nulliparous nonpregnant women. No previous study has documented the magnitude of zinc deficiency among nulliparous nonpregnant women in India. In the present study, the mean serum zinc level was 74.2 ± 23.1 µg/dl. Comparable mean serum zinc levels among nonpregnant women were reported by Rathi et al. (69.0 ± 3.22 µg/dl) [9] and Yasodhara et al. (78.1 ± 21.85) [10]. The dietary pattern of the nulliparous nonpregnant women in our study may have been similar to that of subjects in ear-

<table>
<thead>
<tr>
<th>Zinc level (µg/dl)</th>
<th>Study subjects</th>
<th>Mean ± SD zinc level (µg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 70.0</td>
<td>107</td>
<td>56.1 ± 12.5</td>
</tr>
<tr>
<td>≥ 70.0</td>
<td>151</td>
<td>87.0 ± 20.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>RDA</th>
<th>Mean ± SD dietary intake</th>
<th>No. (%) of subjects having dietary intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>15 mg</td>
<td>6.0 ± 2.3 mg</td>
<td>&gt; 75 % RDA: 9 (37) 50%–75 % RDA: 46 (20.6) &lt; 50 % RDA: 170 (75.7)</td>
</tr>
<tr>
<td>Protein</td>
<td>50 g</td>
<td>48.6 ± 27.5 g</td>
<td>&gt; 75 % RDA: 214 (95.2) 50%–75 % RDA: 8 (3.4) &lt; 50 % RDA: 3 (1.4)</td>
</tr>
<tr>
<td>Calories</td>
<td>1,875 kcal</td>
<td>1,564.7 ± 410 kcal</td>
<td>&gt; 75 % RDA: 152 (67.4) 50%–75 % RDA: 57 (25.2) &lt; 50 % RDA: 16 (7.3)</td>
</tr>
</tbody>
</table>
lier Indian studies [9, 10], as the serum zinc levels were similar. Bahl et al. (82.2 µg/dl) [11], Prema et al. (110 µg/dl) [12], Goel and Misra (120.5 ± 7.7 µg/dl) [13], Kapoor et al. (121 ± 4.0 µg/dl) [14], and Ghosh et al. (127.32 ± 17.65 µg/dl) [15] reported higher serum zinc levels among nonpregnant women than those in our study. This may be possibly due to higher intake of zinc by the nonpregnant women in these Indian studies.

Zinc deficiency is common in areas where the population subsists on diets low in dietary zinc and/or with low bioavailability of zinc. The bioavailability of zinc in the diet is influenced by the food source as well as the other components of the diet that inhibit or promote the absorption of zinc. The primary inhibitor of zinc absorption is phytic acid, which is present in significant amounts in staple foods such as cereals, maize, and rice. The main source of energy (90%) of the women in the present study was cereals (wheat). Consumption of such cereal-based diets, which are high in phytic acid, leading to low bioavailability of zinc, is a possible reason for the high prevalence of zinc deficiency.

Although a high prevalence of zinc deficiency has been documented among women of developing countries, the functional significance of such deficiency is not yet understood. Zinc-supplementation trials conducted among pregnant women in developing and developed countries have reported mixed results. The majority of the trials have reported an increase in birthweight and a reduction in very preterm (< 32 weeks) and very-low-birthweight (< 1,500 g) babies [16–19]. A few studies have documented no positive impact of zinc supplementation on birthweight and on the prevalence of large-for-gestational-age infants, small-for-gestational-age infants, premature rupture of membranes, and preterm labor [20–22]. However, most zinc-supplementation studies have documented a positive impact. A recently conducted technical consultation [23] on the public health importance of maternal zinc deficiency recommends future research among populations that are at high risk for adverse pregnancy outcomes. Dietary zinc and other dietary constituents affecting zinc absorption should also be studied. Zinc-intervention trials should begin not only during gestation but also before conception [23]. The findings of our study support these recommendations.

Acknowledgments

We duly acknowledge the financial support of Vide Project No. 5/9/5/2000-RHN, provided by the Director General, Indian Council of Medical Research, New Delhi, for the present study. The infrastructure facilities provided by the Director, All India Institute of Medical Sciences, are also acknowledged.

References

15. Ghosh A, Fong LYY, Wan CW, Liang ST, Woo JSK, Wong
Zinc deficiency among nulliparous nonpregnant women


To the Editor:

Vitamin A deficiency is a worldwide nutritional scourge, and the situation seems to be deteriorating in some parts of the world, such as sub-Saharan Africa [1]. The role of provitamin A carotenoids in the control of hypovitaminosis A has been a particular interest at CeSSIAM [2], and a landmark event in gaining a valid perspective on the issue was the publication of the relevant section of the dietary reference intakes [3], which defined the retinol activity equivalent (RAE) in January 2001. Prior to that date, the value of provitamin A carotenoids in food matrices had been overvalued by the application of the conventional 1:6 and 1:12 bioconversion factors, producing falsely high estimates of population vitamin A security and illusory aspirations to improve vitamin A status by promoting green and orange vegetables [2]. However, the potential for the carotenoids in edible oils to contribute dietary vitamin A activity had been severely undervalued by the same factors, since the dietary reference intake RAE proposes a three-times-greater bioefficacy for emulsified provitamin A carotenoids in an oil base [3].

The Food and Nutrition Bulletin has been in the forefront in providing information on the dietary context of oil-based provitamin A sources [4, 5], and an additional example was the recent publication by Vuong and King [6] on the chemical and nutritional context of the gac fruit (Momordica cochinchinensis Spreng). As stated in their text on p 228: “The total carotenoid concentration of gac fruit oil is 5,770 ppm, consisting mainly of two carotenoids, β-carotene and lycopene” [6]. We were troubled, however, when trying to get a handle on the dietary vitamin A value of the oil of this fruit compared to that of the palm fruit (genus Elaeis) [6], encountering a host of internal and external inconsistencies. For the sake of clarity in the international discussion and toward an informed use of appropriate dietary approaches to hypovitaminosis A, we raise some of these inconsistencies.

The confusion derives in part from internal inconsistencies in the concurrent expression of nutrient concentration both per milliliter of oil and per 100 ml of edible portion of oil. Table 2 from Vuong and King [6] provides values for “β-carotene and isomers” in units of micromoles per milliliter (μg/ml) as 2,710 μg/ml for freshly prepared gac oil and 1,622 μg/ml for the same oil after three months of storage. However, in their table 5 (a comparative table of nutritional quality of gac fruit oil and of other fat and oil sources), in which the expression is per 100 g of edible oil, there is a disconnect: the vitamin A activity in retinol equivalents for gac oil is presented as 40 RE for data from the same article [6].

The external inconsistency is a similarly invalid conversion factor calculation for the red palm oil (RPO), reported by Nagendran et al. [7] as 8 RE in Vuong and King’s composite table 5 [6]. We have created a table in this letter, comparing the values of Vuong and King [6] and those of Nagendran et al. [7], along with information on the molecular-distilled RPO product, Carotino, published by Scrimshaw [8]; all are expressed for 100 g (approximately 100 ml) of edible oil (table 1). Indeed, with a uniform denominator, fresh gac oil would still have about five times the vitamin A activity of crude RPO, but the RE value, itself, is over 100 times what Vuong and King [6] presented in their table 5. Retinol equivalents, however, use a 1:6 conversion efficiency.
assumption. With the newer, US/Canada DRI conversion of 1:2 [3], with its retinol activity equivalent convention, the effective, maximal dietary vitamin A activity is still three times higher (see final column of our table).

Provitamin A–containing oils, by virtue of their intrinsic safety and cultural application as food in a dietary context, have much to contribute in the public health campaign to eradicate hypovitaminosis A. Therefore, we felt it important to set the record straight and rectify the RE expression in the Vuong and King article [6], while pointing out how the potential vitamin A activities of carotene-rich oils from fatty fruits are raised even further in the context of the latest insights into provitamin A bioconversion [3].

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Mónica Orozco
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Guatemala City, Guatemala

References

Authors’ response

To the Editor:

We are indebted to Drs. Solomons, Orozco, and Ventura for the corrections, and for the calculations.

The units in the headings for two columns of table 5 in our paper were incorrect: For both carotenes and vitamin A, the column heading should have specified mg instead of μg. We are resubmitting the following Table 5 as an erratum.

L. T. Vuong
J. C. King

In response to Natera et al., “Estimation of daily micronutrient intake of Filipinos”

To the Editor:

I am writing in regard to an article in the Food and Nutrition Bulletin Supplement (Vol. 23, No. 3, September 2002, pp. 222–227). The study is “Estimation of daily micronutrient intake of Filipinos” by Natera et al. I would like to raise some points regarding the clarity, accuracy, and coherence of the paper.

The study compared two sets of data on nutrient content of one-day diets of Filipinos, a comparison that suffers from two serious limitations. The nutrient intake reported in the first study in 1992 came from only one region (National Capital Region) using only eight samples [1]. On the other hand, the intake data in the second study in 2000 came from several regions of the country, numbering 9 or 13, depending on which section of the paper is read [2]. A second limitation is the large variations in food items for the diet samples used during the two-year duration of the second study.

The noncomparability of the two studies precludes any conclusions about nutrient intakes having increased or decreased from one period to the next. The limitations of the study and the extent to which they undermine the potential use of the collected data should have merited some attention from the authors, given their claim as to the study’s usefulness in terms of addressing the malnutrition problem of the country, redefining nutrition strategies, and serving as a basis for assessing dietary requirements.

In two instances, the text and the corresponding table do not agree. One example is fruit intake (83 g in the text but 77 g in table 1). Another example is milk and milk products (56 g in the text but 44 g in table 1).

According to the authors, the 0.38 μg of iodine in their 2000 study was significantly less than the iodine content of approximately 65 μg in the Filipino diet, and they explained that “the decreased values maybe [sic] due to a loss of iodine in the cooking process.” It should be noted that the 0.38 μg of iodine is the amount per gram of dry diet sample, whereas the 65 μg is the estimated iodine content of the average Filipino diet (reference 3, p. 181).

There is some confusion about nutrient recommendation and nutrient intake. For example, the authors said that “The average phosphorus intake of Filipinos, estimated to be 976 mg per day, while the calcium
intake is approximately 450 mg per day,” but based on table 3 these figures refer to the 1989 RDA, and the 2000 mean intakes were 564 mg for phosphorus and 251 mg for calcium. A similar error was made in reference to the RDA and the intakes of sodium and potassium.

It is not clear how the authors arrived at some statements in the Results and Discussion section of the paper. For example, “This study reports a mean intake of 8.35 mg of iron while in 1992 it was 5.8 mg, which coincides with the problem of iron-deficiency anemia present in 37.2% of the Filipinos in 1993,” Or, “it is safe to present the data as typical intake values” after pointing out the large regional variations in intake due to the seasonality of foods. Or, declaring that “Hence establishing the safe range of nutrient intake for the Filipino may be simple, while establishing a nutrient requirement to prevent detectable signs of impaired function may be complicated” from a prior statement about regional variations in habitual food consumption. A one-day diet is hardly the basis for claiming habitual intake. Moreover, the regional variations in intake were not presented.

Finally, the conclusion that intakes of calcium and sodium in 2000 were generally larger than those reported in 1992 is not supported by the findings of the study.

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We are grateful to Dr. Joe Wray [1] for his strongly positive reaction to our findings about the importance of protein availability to growth [2] and for his contribution to the discussion by reference to several more studies concerning food intake, infection, and growth in young children. It is particularly noteworthy that the studies in India, Colombia, and Mexico [3–5] all show not only that supplementing the diets of children makes

Authors’ response

To the Editor:

We would like to respond to Dr. Florencio’s letter to the editor regarding the article “Estimation of daily micronutrient intake of Filipinos,” which was published in the Food and Nutrition Bulletin Supplement (Vol. 23, No. 3, September 2002, pp. 222–227).

We would like to express our appreciation for the comments given to the said article. The differences in the figures are errors from the manuscript. With reference to the manner in which the data and other related information are presented, please be advised that the authors have the rightful disposition to interpret and to evaluate the data and other information presented. Considering the regional variables encountered in the sampling of diet plus the limitations of the study, it was emphasized (Conclusions and Recommendations) that additional baseline information is needed.

Finally, regarding the usefulness of the data in terms of addressing malnutrition problems in the country and redefining nutrition studies, it is common knowledge that hard-core evidence or information, no matter how small, is necessary to be able to legislate and promulgate measures to address the existing nutrition problem.

Once again thank you for your comments.

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Reply to commentary on “Malnutrition and dietary protein”

We are grateful to Dr. Joe Wray [1] for his strongly positive reaction to our findings about the importance of protein availability to growth [2] and for his contribution to the discussion by reference to several more studies concerning food intake, infection, and growth in young children. It is particularly noteworthy that the studies in India, Colombia, and Mexico [3–5] all show not only that supplementing the diets of children makes
them grow faster, but that supplementation can offset the negative effect of infection on growth and even, in the case of Mexico, reduce the amount of illness. We concur entirely with Wray’s observation that since it is not feasible to protect children entirely from potentially fatal illnesses, improvements in their diet offer a reliable way to assure that they nonetheless grow normally and are more likely to survive the weaning period. Supplementation may be the single most effective way to prevent childhood deaths in poor populations. (The study in India dealt only with the effect of supplementation on children exposed to measles, and measles infection can be entirely prevented by immunization. The Colombian and Mexican studies, in contrast, dealt respectively with diarrheal disease and with infections of all kinds, which are harder to prevent.)

We note that all three programs employed a supplement with fixed proportions of protein and energy, so none of them throws any light on the question we investigated, which is whether additional protein contributes more to growth than additional energy does. The programs may have differed from one another in the protein/energy ratio, but comparisons among them would be unlikely to reveal whether a higher share of protein would do more to promote growth. There were too many differences among the populations studied and the circumstances under which children were supplemented. Only a program that gave some children higher protein supplements than others, while providing the same number of calories to all, would provide a clear answer to that question.

It is also worth noting that supervised supplementation—assuring that each child actually eats the additional food rather than giving it to the child or parent to take home and share—offers a way to overcome in part the discrimination against girls in the distribution of food and especially of protein, to which Wray and we draw attention. How effective this will be presumably depends on the size of the supplement relative to the children’s regular diet, because if the supplement is small, its contribution can be negated by redistribution of food at home. The effectiveness of supplementation may also depend on the educational impact of the program, particularly if parents change their views of the relative nutritional rights or requirements of boys and girls.

Finally, we thank Wray for emphasizing “the difference between a clinical and a socioeconomic-statistical approach” [1] to the connection between protein and growth. Our caution in recognizing that other factors in the diet besides protein availability may be crucial for growth arose from the socioeconomic-statistical nature of our data and methods. It remains true that human beings are largely made of protein and cannot make protein for their growth and functioning from non-protein sources, so scarcity of protein can hardly fail to affect growth and adult height, whatever other limitations may exist.

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Joanne Leslie
Philip Musgrove

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Do crowded classrooms crowd out learning? Evidence from the Food for Education Program in Bangladesh


Akhter U. Ahmed and Mary Arends-Kuenning

Key words: Bangladesh, food-for-education, school enrollment, targeting

In Bangladesh, pervasive poverty has kept generations of families from sending their children to school, and without education, their children's future will be a distressing echo of their own. Many children from poor families in Bangladesh do not attend school either because their families cannot afford books and other school materials, or because the children contribute to their family's livelihood and cannot be spared. In some areas, there is also a lack of schools. Among those who enter primary school, only about 40 percent of them complete it. The great success of the Food for Education (FFE) program of the Government of Bangladesh has led to larger classes, but do these crowded classrooms crowd out learning?

How does the FFE program work?

The Government of FFE program launched the FFE program in 1993. The FFE program provided a free monthly ration of food grains to poor families in rural areas if their children enrolled in primary school, and maintained an 85 percent attendance rate. The family could consume the grain, or sell it and use the cash to meet other expenses. Before the program was terminated in June 2002, the FFE program covered about 27 percent of all primary schools and enrolled about one-third of all primary school students. FFE beneficiary students accounted for about 13 percent of all students in primary schools in Bangladesh. The cost of the program (including the value of food grains) was approximately US$37 per beneficiary student per year. A two-step targeting mechanism was used, selecting poor areas, then poor households within those areas.

Data from school and household surveys conducted in Bangladesh by the International Food Policy Research Institute (IFPRI) in September-October 2000 were used to evaluate the FFE program. The surveys included primary schools with and without the FFE program, and a cross section of households including program beneficiaries and nonbeneficiaries. The sample included 600 households in 60 villages in 30 unions in 10 thanas, and 110 schools in the same 30 unions from which the household sample was drawn. In addition, a standard academic achievement test, designed to assess the quality of education received by students, was given to students in both FFE and non-FFE schools.

The impact of the FFE program

IFPRI analysis showed that the FFE program led to increased enrolment and class attendance rates, particularly among girls. However, classrooms of FFE schools became more crowded: on average, classrooms in FFE schools had 22 percent more students (67 students) than classrooms in non-FFE schools (55 students). Within FFE schools, the average test score is lower for FFE beneficiaries than nonbeneficiary students, which brings down the aggregate score in FFE schools. In non-FFE schools, average test scores of all students are comparable to nonbeneficiaries in FFE schools. Boys consistently outperformed girls in the achievement test in all subjects in all types of schools, regardless of FFE beneficiary status.

Does classroom crowding (resource dilution) or the lower ability of FFE children (peer effect) affect test scores of non-FFE students in FFE schools? IFPRI’s multivariate analysis does not support the resource dilution hypothesis. Class size has no effect on student achievement.

Results of the peer effect analysis, however, show that the learning performance of non-FFE students in FFE schools is negatively affected when an average of 44 percent of the students in class are FFE beneficiaries. This is probably due to the teachers having to go more slowly to accommodate poorly performing FFE students. These students come from poorer families. Evidence from household surveys show that children from poor families are less likely to have educated
parents who could help them in their studies at home, to afford study materials, and to find enough time to do the homework, as many of them must contribute to their family’s livelihood. Moreover, from birth, these children are often deprived of the basic nutritional building blocks that they need in order to learn.

Nevertheless, there are benefits to non-FFE beneficiaries from being in an FFE school because FFE schools must meet certain minimum educational quality standards to maintain FFE eligibility. For example, in FFE schools, at least 10 percent of Grade 5 students must qualify for the national annual scholarship examination. No such performance standards are required for non-FFE primary schools. These benefits to non-FFE beneficiaries outweigh the negative peer effects up to the point when FFE beneficiaries reached 69 percent of the students in the classroom. After 69 percent, the benefits derived from minimum performance standards vanish.

The overall effect at the community level is measured by the Minimum Learning Achievement, the percentage of children in a community who attain a minimum achievement score, weighted by the enrolment rate in that community. The minimum learning achievement in FFE communities is higher than in non-FFE communities (despite the latter tending to be richer) due to the increased enrolment from the FFE program. Particularly, major benefits accrued to the children from poor families who would not have attended school without the FFE program.

Results and conclusions

As a food-based social safety net, the FFE program in Bangladesh served a wider purpose than simply providing the poor with immediate sustenance through take-home food rations, important as that is. It has empowered children from poor families with education, thereby paving their pathway out of poverty.

The FFE enrollment increase was greater for girls than boys, yet boys consistently outperformed girls on the achievement tests. Having drawn them into school, improving the quality of girls’ education will ultimately strengthen the beneficial effects of women’s education on various family-level outcomes, such as children’s schooling, child health and nutrition, and women’s fertility.

The concern that learning performance of non-FFE students in FFE schools may be adversely affected by increased class size generated by the FFE program appears to be unfounded. But, unchecked, the negative peer effect could hinder student achievement. In the FFE program, this was offset by the required minimum educational quality standards. Setting clear standards for performance is important, even at the primary level. Minimum performance standards should be incorporated in the design of the recently implemented Primary Education Stipend program (a cash-for-education program that has replaced the government’s FFE program), as well as in the ongoing pilot testing of the school-feeding program launched by the Government of Bangladesh with support from the World Food Programme.

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The impact of PROGRESA on food consumption

John Hoddinott and Emmanuel Skoufias

Key words: Caloric availability, food consumption, PROGRESA, Mexico

Together with 16 other Millennium Development Goals, the global community has committed itself to halving by 2015 the proportion of the world’s population that lives in poverty and suffers from hunger. While the goals of reducing poverty and hunger may seem intertwined, a review of the existing literature suggests this may not be the case. This paper contributes to this debate, using an analysis based on the impact of Mexico’s Programa de Educación, Salud y Alimentación (PROGRESA).

Background

Since 1997, PROGRESA has provided cash transfers linked to children’s enrollment and regular school attendance and to health clinic attendance. The program also includes in-kind health benefits; nutritional supplements for children up to age five, and pregnant and lactating women; and instructional meetings on health and nutrition issues. In 2000, PROGRESA reached about 40 percent of all rural families and about 11 percent of all Mexican families.

This paper explores whether PROGRESA improves the diet of poor rural Mexicans—a major objective of the program. As such, this evaluation provides insights into whether interventions designed to alleviate poverty also succeed in reducing hunger.

Data and methodology

When PROGRESA began in 1997, it was not administratively feasible to provide benefits to all households simultaneously. Therefore, communities were randomly selected for participation (treatment localities), and the rest were introduced into the program at later phases (control localities). We exploited this random allocation to explore whether PROGRESA improved the diet of poor rural Mexicans and to gain insights into whether interventions designed to alleviate poverty also succeed in reducing hunger.

We used a longitudinal sample of approximately 24,000 households from 506 communities located in the first states receiving PROGRESA benefits. Of the 506 communities, 320 were designated as treatment and 186 as control communities. In control localities, the incorporation of beneficiary households into PROGRESA was postponed until the year 2000.

We first compared potential beneficiaries in treatment areas to those in control areas. This provided an estimate of the impact of PROGRESA inclusive of errors in the operational aspects of the program. Next we examined whether PROGRESA has an impact conditional on households receiving monetary benefits.

To explore whether PROGRESA led to an increase in the physical consumption of food, we constructed a measure of caloric availability at the household level expressed in calories per person per day. The November 1998 survey round revealed several noteworthy features. The first is the monotony of the diets of poor households, with calories from grains accounting for about 75 percent of caloric availability. Second, there was a statistically significant difference in the unconditional means across these poor households (though the magnitude of the difference was small). However, as we moved from November 1998 to June 1999, and then to November 1999, the magnitude of these differences increased. By November 1999, households receiving PROGRESA benefits had, at the mean, 7.8 percent more calories available per person per day than did comparable households in control localities. Particularly striking were the increases in calories consumed from vegetables and fruits and meat and animal products.

A parametric analysis revealed that the conditional impact of PROGRESA on poor households was generally smaller than the unconditional impacts and that there was little evidence of much of a statistically significant impact on caloric availability as of November 1998. This was not surprising, given that an
examination of administrative records indicated that PROGRESA had undertaken only limited operations at the time of this survey. By contrast, in June 1999, households receiving PROGRESA benefits in treatment localities obtained 4.3 percent more calories than did comparable households in control localities. And in November 1999, the effect is even higher: households receiving benefits obtained 7.1 percent more calories than did comparable households in control localities, with much of these gains coming about through increased acquisition of calories from vegetable and animal products—a finding consistent with the view of respondents that PROGRESA was enabling them to “eat better.”

We examined whether these changes in caloric acquisition were driven by increased incomes or by another feature of PROGRESA, the platicas. As part of the program, beneficiaries attend a series of lectures (platicas) where information on health and nutrition is provided by a doctor or nurse. Although participation in PROGRESA raises the amount of calories acquired from grains and other foods, this would appear to be entirely due to PROGRESA’s income effect. However, even after controlling for this effect, participation in PROGRESA appears to have an impact on the acquisition of calories from fruits, vegetables, and animal products. It is possible that this reflects the influence of the platicas beneficiaries attend, where they are encouraged to eat a more diverse diet, including more fruits, vegetables, milk, and other animal products. There is some evidence that information conveyed during these meetings spills over and positively affects the behavior of nonbeneficiaries in treatment localities. We also observed this effect in households with preschool children, which is significant for Mexico, where poor quality diets inhibit the physical growth of children less than 30 months.

Lastly, we examined whether provision of the papilla nutrition supplement—another component of PROGRESA—crowded out the acquisition of calories, but found no evidence that this was the case.

Conclusions
In examining the impact of PROGRESA on household food consumption, we had to be conscious of the survey design with which we worked, the manner in which PROGRESA operated, and the need to specify the functional form relationship between caloric acquisition and incomes. Controlling for differences in household and municipality characteristics, as well as differences in prices among municipalities, we found that there is no evidence of a statistically significant impact of the program on caloric availability as of November 1998, not surprising, since PROGRESA had begun only limited operations at the time of this survey.

However, there is evidence of a significant impact in June and November 1999. By November 1999, households receiving PROGRESA benefits in treatment localities obtained 7.1 percent more calories than did comparable households in control localities. The impact is greatest on the acquisition of calories from vegetable and animal products. Some of this impact is an income effect; some may also reflect attendance at platicas.

More generally, these results suggest that efforts to reduce poverty in the developing world will also reduce hunger.
Books received


The world is experiencing an increasingly serious epidemic of obesity that represents environmental changes to which humans are not genetically adapted. The author, one of the world’s leading authorities on obesity and its causes, has updated the epidemiological data in many tables and figures and reviewed in detail genetic and environmental mechanisms. The hundred pages of figures and illustrations clearly and comprehensively focus on the clinical approach to the problem when prevention fails. These are based on the author’s years of successful teaching and research. What is still needed is a companion atlas giving similar coverage to the prevention of obesity.


This volume is devoted to the history of early field studies demonstrating the importance of preventive care as well as curative medicine in community-based health care. It is of interest to the nutrition community not only because nutrition interventions are an integral part of preventive medicine at the community level, but also because it provides concise summaries of several classic field studies of the effects of nutrition and health interventions at the community level. These are the Bangladesh Rural Advancement Committee-International Center for Diarrheal Disease Research, Bangladesh (BRAC-ICDDR,B) study in Bangladesh, the Narangwal study in India, the Hospital Albert Schweitzer (HAS) study in Haiti, and the Save the Children Study in Vietnam. For those interested more broadly in the community-based approach to nutrition and health care, this is a rare series of first-hand accounts of the development of community-based medicine that led to the WHO Alma Ata declaration and shaped contemporary approaches to primary health care.


This report of a joint WHO/FAO Expert Consultation reviews the evidence on the effects of diet and nutrition on chronic diseases and makes recommendations for public health policies and strategies that encompass societal, behavioral, and ecological dimensions. Although the primary aim of the Consultation was to set targets related to diet and nutrition, the importance of physical activity was also emphasized. The Consultation considered diet in the context of the macroeconomic implications of public health recommendations on agricultural and the global supply and demand for fresh and processed food. In setting out ways to decrease the burden of chronic diseases such as obesity, type 2 diabetes, cardiovascular disease, and osteoporosis, the report proposed that nutrition be placed at the forefront of public health policies and programs.

This report shows how, at the population level, a good diet and exercise throughout life are necessary to reduce the threat of a global epidemic of chronic disease. The report will be useful to medical and public health professionals everywhere. (Adapted from WHO promotional materials.)


By far the largest number of malnourished children
are in Asia, and this burden is persisting at the same time that another is emerging: overweight with its linkages to chronic degenerative diseases in later life. What makes this even more alarming is the growing evidence that children malnourished in utero and in infancy undergo metabolic changes that make them more vulnerable to such disease if they are no longer nutritionally deprived as adults.

This book looks at the prevalence of under- and overnutrition as well as chronic disease in the countries of Asia. As economists, the authors look at both the human and the economic costs of this double burden and go on to identify options for remedial action in the different countries. The need for a life-cycle approach to the problem has been increasingly recognized by the international agencies and is adopted by the authors in identifying the risks in Asian countries at each stage of the life cycle and what is practical to do about them.

Although the book is small, its approach is remarkably comprehensive. Extensive tables present a profile of malnutrition in Asia according to source, direct and indirect actions to reduce malnutrition, and prevention of malnutrition by addressing underlying causes. Another table goes even further by listing a series of actions for reducing malnutrition through “developing an enabling environment and indicating how each can be achieved.” For those concerned with developing or implementing programs and policies to deal with malnutrition not only in Asia but in other developing regions, this volume provides a useful guide and checklist.


One of the most important health findings in recent decades is the extent to which loss of strength and mobility with aging can be slowed and even reversed with strength training. This is in addition to previous knowledge of the strong relationship of lack of aerobic exercise with obesity and chronic degenerative diseases such as diabetes, hypertension, and ischemic heart disease.

Regardless of longevity, men have several more years of quality life than women. Yet until recently, most aging research was focused on men. This book explores the factors responsible for gender differences in morbidity and mortality with aging, including the extent to which these are determined by social and economic factors rather than biological differences. It notes that gender comparisons between men and women are confounded by discrepancies in body size and composition. The contribution of diminished physical activity in both men and women to the overall loss of functional capacity and fitness and the difference between the sexes is explored.

In successive chapters a distinguished panel of authors systematically explores the impact of gender and habitual physical activity on specific physiologic, biological, biochemical, and pathological features of the aging process important to physical performance, independence, and quality of life for the elderly. Although this volume will appeal particularly to professionals working in geriatrics, it will also be of interest to all concerned with the nature and impact of human aging as well as how it is influenced by environmental factors.


There is no longer a need to extol the benefits of breastfeeding or the extent to which failure to breastfeed is associated with high infant mortality in developing countries. Just as a consensus was being achieved on the importance of promoting breastfeeding under all circumstances, the rapidly spreading epidemic of HIV/AIDS introduced a tragic complication. As evidence mounted that under some circumstances HIV/AIDS could be transmitted to the infant by breastmilk, this posed a major crisis for the breastfeeding movement. It has been established that breastfeeding by untreated HIV-positive mothers passes the virus to the infant in about one-third of cases, and an average of 15% of babies breastfed for two years develop HIV/AIDS. Yet many of these infants would die anyway if they did not receive breastmilk.

Facing this dilemma, UNICEF, with the World Alliance for Breastfeeding Action (WABA), convened a colloquium on HIV and Infant Feeding in Arusha, Tanzania, in September 2002. This paperback is the report of the meeting. The meeting summary provides much useful information, but the closest that it comes to resolving the issue is the statement “HIV and infant feeding risk assessment should include an assessment of the mother’s health and nutritional status, availability of nutritional support, family context and prevailing social and environmental conditions.” It fails to indicate how to use these data to decide what feeding regimen to recommend.

There can be no criticism of the summary’s emphasis on priority research, on strengthening health systems, on improving monitoring and evaluation, and on a wider sharing of existing tools, guidelines, and manuals. But nutrition and health workers need more specific recommendations as to what decisions to make in the field. Some kind of decision tree, even if provisional, is lacking.

Most chapters in this book deal with the demographic effects of specific infectious diseases in recent centuries, but the opening chapter has a substantive section on the relationships between malnutrition and famine and susceptibility to infectious diseases and death. The chapter on infectious diseases in England and Wales in the nineteenth century emphasizes this relationship. Other chapters refer to the relationship of malnutrition to infant mortality, child mortality, population dynamics and population growth, pregnancy, and susceptibility to disease. Chapters exploring the population impact of cycles in grain prices and the price of wool in seventeenth-century England also have obvious nutritional implications. However, this book is more for economic historians and demographers than for nutritionists.


This is a good elementary text for undergraduates studying nutrition as part of training in biology or life sciences. For students majoring in nutrition it does not replace textbooks with more comprehensive coverage of the molecular and metabolic basis for malnutrition.


This Reference Document on Poverty and Health, jointly published by the Organization for Economic Cooperation and Development (OECD), extends the analysis and recommendations of the OECD/WHO Committee on Development Assistance (DAC) Guidelines on Poverty Reduction [1] by setting out the essential components of a public health approach that benefits the poor. It provides a framework for action within the health system—and beyond it, through policies in other sectors and through global initiative.

The nutrition and health of the poor has become a critical development issue. The publication emphasizes that in addition to the intrinsic value of improved health for individuals, investment in health is an important and previously underestimated means of economic development; substantially improved health outcomes are a prerequisite if developing countries are to break the cycle of poverty. The document is aimed at a broad range of professionals working on policy and its implementation at headquarters and in the field in both international and national agencies.

**Reference**


Doctoral theses are occasionally reviewed in the Bulletin when they are formally published and meet the Bulletin criteria for usefulness and originality. The diets of rural Ethiopian populations are relatively high in total iron and zinc, but because of their high content of phytates and tannins, the bioavailability of iron and zinc is low. Evidence is presented that zinc supplementation increased both linear and ponderal growth in both stunted and nonstunted children, with a greater effect on those who were stunted. Unfortunately, this effect can be reversed if zinc supplementation is discontinued.

Zinc supplementation of stunted children in rural Ethiopia also resulted in markedly lower morbidity from cough, diarrhea, fever, and vomiting. This small paperback demonstrates the importance of determining the role of zinc deficiency in the stunting that is so highly prevalent among young children in most developing countries. This study and others that are appearing regularly in the scientific literature give increasing reason to include zinc in the multiple fortification of cereal flours.
News and notes

IVACG, INACG, and IZiNCG Meetings 2004

Meetings of the International Vitamin A Consultative Group (IVACG), International Nutritional Anemia Consultative Group (INACG), and International Zinc Nutritional Consultative Group (IZiNCG) will be held in Peru in mid November 2004.

There will be joint sessions on interactions from the metabolic to the policy levels among deficiencies of the three nutrients (vitamin A, iron, and zinc) and their control.

For specific dates and details on submitting abstracts, please check the following websites:

IVACG ivacg.ilsi.org
INACG www.izincg.ucdavis.edu
IZiNCG inacg.ilsi.org

SCN News (UN System Standing Committee on Nutrition)

SCN News (ISSN 1564-3751) is a periodic review of developments in international nutrition compiled from information available to the SCN. SCN News aims to help the sharing of experience in nutrition and is now published twice yearly. Recent issues have featured articles on Nutrition in the Context of Conflict and Crisis (#24), Nutrition and Health of School-age Children (#25), and Mainstreaming Nutrition for Improved Development Outcomes (#26). Publication of items in SCN News does not imply endorsement of views given, nor necessarily the official positions taken, by the SCN and its member agencies. The SCN gratefully acknowledges funding assistance from the Government of The Netherlands for the preparation and printing of SCN News.

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Food and Agriculture Organization (FAO) www.fao.org
International Atomic Energy Agency (IAEA) www.iaea.org
International Life Sciences Institute www.ilsi.org
International Nutritional Anemia Consultative Group (INACG) inacg.ilsi.org
International Vitamin A Consultative Group (IVACG) ivacg.ilsi.org
International Union of Nutritional Sciences (IUNS) www.iuns.org
Micronutrient Initiative www.micronutrient.org
Pan American Health Organization (PAHO) www.paho.org
Save the Children www.savethechildren.org
United Nation Children’s Fund (UNICEF) www.unicef.org
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- The United Nations University (UNU)
- The International Atomic Energy Agency (IAEA)
- The United Nations Children’s Fund (UNICEF)

**Bilateral agencies**

- International Life Sciences Institute (ILSI)
- Micronutrient Initiative (MI)
- United States Agency for International Development (USAID)

**Corporations**

- AK Nobel
- Kraft Foods
- Procter & Gamble
- Roche
Training in Public Nutrition at Emory University, USA

The Department of International Health of Emory University now offers an MSPH degree in Public Nutrition. This new two-year program of study provides a comprehensive understanding of major nutrition problems afflicting people in both wealthy and poor nations, as well as the policies and programs to address them. The program is distinguished by an emphasis on methods, especially nutrition assessment, epidemiology, biostatistics, research design and survey methods, program design, monitoring and evaluation, and policy analysis. Opportunities and funding for summer field-work anywhere in the world are available to students on a competitive basis. For additional details, including financial aid, interested applicants are encouraged to visit our web site (http://www.sph.emory.edu/nutrition) or write to MSPH Degree, Department of International Health, Rollins School of Public Health, Emory University, 1518 Clifton Road, N.E., Atlanta, GA 30322.
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Note for contributors to the *Food and Nutrition Bulletin*

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