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Editorial

Use, acceptability, and cost of Incaparina

This issue contains an article on the use, acceptability, and cost of Incaparina [1]. When the product was introduced commercially in Guatemala in 1961, it was the first successful effort to produce a low-cost, vegetable-based weaning food using indigenous raw materials and adapted to local food habits and tastes. It was based on the local popularity of cereal-based gruels known as *atoles*, although these were poor in protein and other essential nutrients. INCAP (Institute of Nutrition for Central America and Panama) was motivated to develop such a food because milk and other animal protein sources were prohibitively expensive for the poor and the severe protein deficiency kwashiorkor was common.

At the time that it was introduced, the cost of Incaparina was one-fifth the cost of an equivalent amount of milk, and it soon came to be accepted and widely used. It was criticized because it still did not reach the poorest of the poor, but unlike attempted introductions of similar products in other countries at the time, it succeeded commercially without subsidy by the government or any other agencies. It continues to make a valuable contribution to the nutrition of both children and adults in Guatemala.

As noted in the article in this issue, Incaparina underwent extensive animal testing before its introduction [2]. It was then given to well children in the metabolic ward, where it was shown to have a protein value equivalent to that of milk when both were fed at requirement levels [3]. It was next tested under practical conditions in the field, where it proved not only to be acceptable but to result in less prolonged and severe diarrhea than milk [4]. Ultimately it was shown to be as effective as milk in the treatment of kwashiorkor [5]. Over the nearly 40 years since its introduction, it has maintained an enviable reputation and has a steady demand.

At the time of the Latin American Nutrition Society (SLAN) meeting in Guatemala in 1998, despite many necessary price increases and devaluations of the currency, the price of Incaparina was still one-fifth that of milk. Moreover, the local manufacturer could not produce enough to satisfy the market because of difficulty in obtaining suitable cottonseed flour, even though the original formula had been changed to include 10% soy flour to spare some of the cottonseed flour. It is ironic that soy flour was not used in the initial formula for Incaparina, because it was thought that it would always need to be imported. At the time, cotton was a very profitable crop in Central America, and a great deal of cottonseed meal was being exported to Europe. As cotton production has fallen in the region, there has not been enough available local cottonseed flour of suitable quality. The producer attempted to obtain additional cottonseed from the United States but encountered problems of quality and cost. Whether the attempt to introduce a soy-based formula will be successful in a population accustomed to the flavor of cottonseed remains to be seen.

By any reasonable criteria, Incaparina has been a great and sustained success, not only for its value to Guatemala but also because of the stimulus it has provided to other countries. Incaparina was never presented to the world as a formula to be copied but as a principle that could be adopted by any country. It was pointed out that approximately one-third of any locally available oilseed meal, such as that from sesame, peanut, or slightly more of other legumes, could be used with equal success. The challenge is to market the formulation in a locally acceptable form. Fortunately, the custom of consuming cereal gruels is very widespread.

For example, soon after Incaparina was introduced, India suffered a major food crisis, and despite huge amounts of donated wheat, malnutrition sharply increased in young children. Building on the INCAP experience, the Central Food Technological Institute came up with a formula using locally available peanut meal and donated wheat that proved highly acceptable. It was given the name *Bal Ahar* ("nutritious child food" in many Indian dialects). Four plants were built to produce it as a government-subsidized relief food, and this product continues to be used for this purpose today.

It is hoped that the evidence for the continued usefulness of the Incaparina principle will continue to encourage other developing countries to renew their efforts to make available low-cost weaning foods for their people using local resources. Such low-cost, nutritious foods can and should be available in every developing country in which much of the population cannot afford sufficient milk and other foods of animal origin for their children.

Nevin S. Scrimshaw, Editor
Founding Director of INCAP (1949–1961)

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Building household food-security measurement tools from the ground up

Wendy S. Wolfe and Edward A. Frongillo

Abstract

For impact evaluation and for planning and targeting decisions, local organizations in developing countries need tools for assessing household food security that go beyond measuring food availability to include access to food and perceptions of food insecurity. This paper explores the potential for developing direct measures of household food security that include such components and that are based on an in-depth understanding of the experience of food insecurity at the household level. This process was used successfully to develop the US Food Security Measure. The US approach and examples of efforts in developing countries are reviewed, along with relevant conceptual and measurement issues. The potential portability and challenges to use of the US approach in developing countries are discussed. The elements needed to apply this approach are outlined, along with operations research needed for developing such experientially based measures.

Introduction

Humanitarian relief and development organizations increasingly need to measure household food security to monitor and evaluate the impact of programs and make planning and targeting decisions. Existing measures of regional or even local food availability often are inadequate for project-level decision-making, since availability is only one component of household food security. Other components, such as access to food and certainty of the food supply, are also important. One way to develop direct measures that include these components and that can complement existing measures is to base them on an in-depth understanding of the experience of food insecurity at the household level, as was used successfully to develop the US Food Security Measure [1]. Although the US measure itself may not be applicable to many developing countries, the approach may well be.

This paper explores the potential for developing improved measures of the access component of household food security based on an in-depth understanding of food insecurity at the household level. Relevant conceptual and measurement issues are discussed, followed by a review of the US approach and examples of efforts in developing countries. These are then used to evaluate the potential portability and challenges to use of the US approach in developing countries. The elements needed to apply this approach are outlined, along with operations research needed for developing such experientially based measures.

Conceptual and measurement issues

How best to measure household food insecurity is the subject of much debate, partly due to the difficulty of defining it [2]. The concept of food insecurity as thought about in the United States includes not only the lack of availability, access, and utilization or use of food (e.g., food preparation and intrahousehold food distribution), but also perceptions (e.g., that food is insufficient, inadequate, unacceptable, uncertain, or unsustainable)(fig.1). For example, food insecurity has been defined in the United States as "the inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so" [3, 4]. Food insecurity as experienced in other locations is likely to be somewhat different but will include similar components that go beyond availability and access.

As shown in figure 1, food insecurity affects dietary intake and, ultimately, nutritional status and physical well-being. Although measures of dietary intake of individuals can assess some aspects of food insecurity, such as caloric insufficiency and nutrient inadequacy, they do not assess the cognitive and affective compo-

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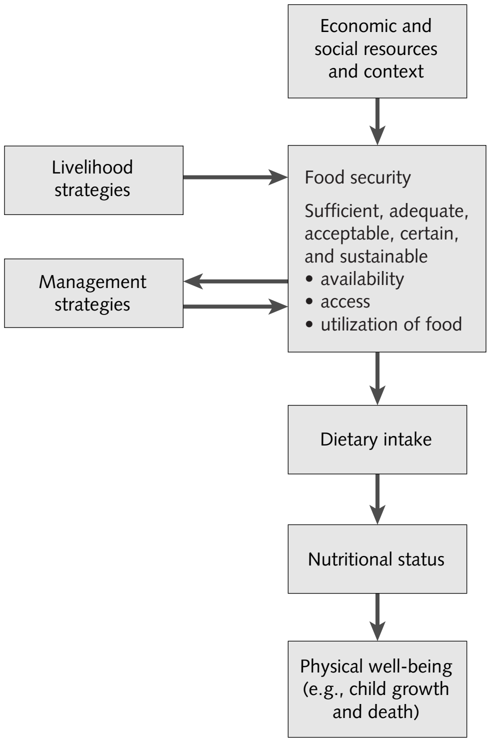

FIG. 1. A conceptual framework based on the understanding of food security in the United States

nents of uncertainty (expressed as anxiety), unacceptability, or unsustainability. For example, current intake may be adequate, but food insecurity may still be experienced because of concern over future intake. Alternatively, intake may be inadequate, but only temporarily to protect supplies and prevent future food insecurity. Growth status is also used as an indicator, but again does not assess most of the components of food insecurity. Furthermore, growth status is an indirect outcome, since it also depends on factors such as health and child care in addition to access. Food insecurity is also related to available economic and social resources. Precursors such as income or total expenditure are correlated with caloric sufficiency, but they only capture this component of food insecurity and are quite indirect [5]. Food-related management or "coping" strategies have also been used to assess food insecurity [6, 7]. Management strategies both result from and impact the experience of food insecurity and may be useful as early indications of future food insecurity. The presence or absence of particular management strategies, however, is often not indicative of food security, and measures of management strategies do not directly assess important aspects of the experience of food insecurity.

Keeping in mind that the closer or more direct a measure is to the phenomenon of interest, the better that measure will be, it is important to measure the experience of food insecurity itself, including whatever its key components are in a given location [8]. This experience could be objectively and definitively measured by observing a household in detail over time along with interviewing members of that household in depth [8, 9]. Since this is not feasible to do for a large number of households, however, this experience can instead be measured subjectively by assessing not only aspects of the availability, access, and utilization of food, but also how a person feels about it (e.g., anxiety or worry) and what a person thinks about it (e.g., perceptions or social acceptability). Because these manifestations are overt, we can tap into them to measure the experience of food insecurity directly in a comprehensive manner.

Establishing validity is fundamental to the development of measures. Validation is the process of determining whether a method is suitable for providing useful analytical measurement for a given purpose and context [8]. This process has been previously described in relation to the development of food-security measures in the United States [8, 10]. In-depth understanding of food security is crucial for developing valid measures, for two reasons. First, for a measure to be valid, its construction must be well grounded in an understanding of the phenomenon. Second, in-depth understanding can be used as the basis for creating a definitive criterion against which a developed measure can be compared [8].

The US National Food Security Measure

The US National Food Security Measure is an example of the use of in-depth understanding to develop and validate a quantitative measure of food security. The measure was based largely on research that involved qualitative, in-depth interviews with low-income, rural women with and without children who had experienced food insecurity [3, 4]. The research concluded that food insecurity is experienced differently at the household, adult, and child levels; adults buffer the effects of food insecurity on children; food insecurity has four components, two related directly to food (quantity and quality of food), and two psychological and social in nature (certainty, which is related to worry about food, and acceptability, which is related to how food is acquired); and hunger is the most extreme consequence of the progression of food insecurity.

Items measuring this understanding of food insecurity were derived from statements that described, in the women's own words, the experience of food insecurity. Twelve of these items (see table 1), which captured most of the food-insecurity components and showed high reliabilities, were subsequently tested in a general population survey of households with children, and the resulting measure was found to be valid. It

TABLE 1. Questions included in the US National Food Security Measurement tool

In the last 12 months, did you or other adults in your household ever *cut the size of your meals or skip meals* because there wasn't enough money for food? How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
In the last 12 months, did you or other adults in your household ever *not eat for a whole day* because there wasn't enough money for food? How often did this happen——almost every month, some months but not every month, or in only 1 or 2 months?
In the last 12 months, did you ever *eat less than you felt you should* because there wasn't enough money to buy food?
In the last 12 months, were you ever *hungry but didn't eat* because you couldn't afford enough food?
Sometimes people lose weight because they don't have enough to eat. In the last 12 months, did you *lose weight* because there wasn't enough food?
In the last 12 months, did you ever *cut the size of any of the children's meals* because there wasn't enough money for food?[a]
In the last 12 months, did any of the *children ever skip a meal* because there wasn't enough money for food? How often did this happen——almost every month, some months but not every month, or in only 1 or 2 months?[a]
In the last 12 months, were the *children ever hungry* but you just couldn't afford more food?[a]
In the last 12 months, did any of the *children ever not eat for a whole day* because there wasn't enough money for food?[a]
"I *worried whether our food would run* out before we got money to buy more." Was that often, sometimes, or never true for you in the last 12 months?
"The *food that we bought just didn't last*, and we didn't have money to get more." Was that often, sometimes, or never true for you in the last 12 months?
"We *couldn't afford to eat balanced meals*." Was that often, sometimes, or never true for you in the last 12 months?
"We *couldn't feed the children a balanced meal* because we couldn't afford that." Was that often, sometimes, or never true for you in the last 12 months?[a]
"The *children were not eating enough* because we just couldn't afford enough food." Was that often, sometimes, or never true for you in the last 12 months?[a]
"*We relied on only a few kinds of low-cost food to feed the children* because we were running out of money to buy food." Was that often, sometimes, or never true for you in the last 12 months?[a]

a. Questions asked only of households with children.

correlated significantly with risk factors for hunger and its dietary consequences, such as consumption of fruits and vegetables and the amount of food available in the household; it differentiated the degree of severity of food insecurity at both the group and the household levels; and it was highly associated with a definitive measure of household food security [10–12]. The definitive measure was developed by using qualitative methods involving expert judgment to integrate extensive information from in-person interviews [12].

This measure, slightly modified, was incorporated, along with some other measures, into a national measure and used in the 1995 National Current Population Survey (table 1). Based on detailed analysis and testing of these data, a numerical food-security scale and a related categorical food-security status measure were developed for use in both national and local surveys to describe the food-security situation of US households during the preceding 12-month period. Further collection, analysis, and testing have established the stability and robustness of the measure across years and across major population subgroups, and its validity has been demonstrated [8, 10].

A key strength of the US measure, and a reason for its success, is that it is well-grounded conceptually. It is based on an in-depth understanding of the experience of food insecurity in US households. The US measure recognizes, for example, the conceptual difference and complex relationship between the experience of food insecurity and strategies to manage or cope with that experience. The US measure does not include items on management strategies, for two reasons. First, when tested, the set of items on management strategies that was available did not meet the statistical criteria for construction into a scale, suggesting that this set of items was not sufficiently coherent and complete. Second, inclusion of these items would not have altered the estimates of prevalence from the measure [13].

Another important strength is that the measure is quick and simple to administer, generally requiring less than four minutes of survey time. This makes it feasible for standard use nationally as well as at state and local levels, creating comparable data that can be aggregated. When used on a periodic basis, the measure can provide systematic monitoring of progress in addressing food-security needs at each of these levels [2].

Another strength is that because each set of items captures a different degree of severity, the measure captures the full range of severity and distinguishes among its different levels. This feature is critical for accurately gauging the prevalence of each level of severity [2].

A weakness of the tool is the focus that was placed on its construction as a unidimensional scale, even though food security is understood to be multidimensional. Construction as a unidimensional scale enabled the use of psychometric theory and models to assess properties of the measure. A model that assumes one dimension, however, is a limited abstraction. Reliance on this model led to creating a four-category indicator of food security, with category labels corresponding to severity. This four-category indicator has been criticized as lacking face validity and being less useful and interpretable than would have been possible. The criticism has primarily focused on the rationale for where the cutoff points separating the four categories were placed, and on the appearance that the categories were defined on the basis of only the severity dimension of food security.

An important consideration for wider use of this approach is that the qualitative research that allowed the measure to be well grounded in an understanding of the experience of food insecurity was very time-consuming, involving in-depth interviews with a large number of women and extensive analyses of these interviews. Operations research is needed to find ways to streamline the process of obtaining in-depth understanding of the experience of food insecurity. Various methods used to understand food insecurity in developing countries are explored below, some of which might be useful for this process.

Methods for understanding food insecurity and developing measures

A number of methods have been used to gain an understanding of food insecurity and to apply this understanding to the development of measures.

Ethnography

Ethnography involves in-depth interviewing and participant observation, usually by living in a community for an extended period of time. It can be used to help develop quantitative measures. For example, Chung et al. used ethnography in south-central India to understand local perceptions, early signs, coping strategies, and intrahousehold decision-making related to food security. From this, unique, locally defined indicators of food insecurity were developed [14]. Ethnography was also used in rural Nepal to help develop culturally appropriate and valid quantitative instruments for assessing and operationalizing household food security and for constructing scales of past food supply, current food stores, and adequacy of future food supply [15]. As described above, in-depth interviews were used to understand US food security and to develop the US measure.

Rapid rural appraisal

A number of simple tools and techniques for assessing problems and situations at the community level have been developed as part of rapid rural appraisal (RRA) and the similar, but more action-oriented, participatory rural appraisal (PRA). These often involve focus groups and in-depth interviews. Information gathered through RRA can be used to understand the food-security situation and to help develop quantitative measures. Examples of a few such RRA/PRA techniques follow [15–19].

Food-security ranking involves asking a diversity of key informants to categorize village households according to the level of food security in the current year and in good and bad years. *Village mapping* is similar but involves asking groups of men and women to draw a map of their neighborhood on the ground, identifying food-insecure households and causes of food insecurity. Criteria used for categorizing households, differences between years, and causes given can be useful for understanding food insecurity in that community.

Food-security calendars are useful for understanding the seasonal dimension of food security. Participants are asked to indicate for each food-security group and for both good and bad years the months in which they eat until they are full and the months they suffer from hunger. Then the calendar is "interviewed," asking about consumption patterns and coping strategies for each group during each period of food security, as well as underlying causes of hunger. *Activity calendars* are similar and involve asking villagers in different food-security categories to distinguish between food-related activities they do in good versus bad years or seasons, including coping and investment strategies, and activities and assets that act as buffers against having to resort to coping.

Bean-ranking is a pictorial method used for a number of different purposes. It can be used to rank households into food-security groups and then "interview" the piles of beans to understand the coping strategies and other characteristics of each group, to develop household "food charts," and to construct histogram-like seasonal charts for rainfall, harvests of staples, food consumption, illness, etc.

Coping strategies

Maxwell [6, 7] developed a method for assessing household food security indirectly through food-related coping strategies, that is, the actions people take when they do not have enough food or money to buy food. In-depth interviews were used to identify coping strategies, then their relative severity was rated by focus groups. A questionnaire assessing frequency of use of each strategy was developed, from which a food-security score is derived by applying severity weightings.

Food-economy approach

The food-economy approach monitors household food security and early warning of food crises by quantifying household access to food in normal years and the effects of external shocks on this [20]. By using in-depth interviews and various RRA techniques, a “baseline picture” describing how different families in a geographic-specific “food-economy zone” normally obtain food and nonfood income is developed, describing sources and means of food and cash income and sometimes expenditure patterns. Potential changes in agricultural, economic, or security conditions that affect families’ access to food are also quantified. A software program called Risk Map is then used to calculate the extent to which these changes affect different households’ overall access to food and the amount this may be reduced by household coping strategies. The results include an estimate of the shortfall in food income that people are likely to face, the costs of coping in terms of depletion of assets and dislocation of families, and the likely effects of different levels and forms of assistance.

Expert systems

Phillips and Taylor [21] developed a method for assessing household food security that combines a household questionnaire with a quasi-expert analysis system. In-depth interviews were used to develop a conceptual model, and then, using a modified Delphi technique, local and national experts identified indicators that were used to help develop the questionnaire. The questionnaire includes both open- and closed-ended questions with locally appropriate responses identified by focus groups. Data analysis uses a complex set of database programs that emulate an expert system, asking questions of the data until it determines the current level of food security of a given household, the amount of food-security “risks” it faces, and the degree of food-security “insurance” it has.

Livelihood security

Based on the assumption that indicators derived from indigenous livelihood systems and methods of prediction and response can outperform conventional famine early-warning systems, Davies developed an approach to food-security monitoring [22]. Field agents live in or near the communities they monitor for a year and use in-depth interviews, RRA techniques, and more conventional surveys, such as market surveys, to understand the local livelihood systems and develop indicators for tracking livelihood vulnerability. These indicators are monitored annually and used to predict needs and develop appropriate interventions.

Analysis of examples

All of these examples contributed to a better understanding of the food-security situation in their respective locations, but none focused on understanding or developing measures based on the experience of food insecurity itself, as in the US approach. The in-depth interviews used in several of the examples, especially combined with RRA techniques, probably provided the information for such an understanding, but the authors focused elsewhere. Chung focused on management strategies to develop targeting indicators [14]. Maxwell obtained detailed understanding of coping strategies [6, 7]. The food-economy model focused on economic resources and production. Davies focused on livelihood strategies to develop indicators of future risk [22].

Thus, although in-depth interviewing of individuals who have experienced food insecurity is needed in addition to focus groups or other RRA methods, obtaining such understanding appears feasible based on these examples. To improve this understanding and help to validate the information collected, methods can be “triangulated” by using different tools with the same groups, and by using different socioeconomic, gender, and other groups to capture intravillage heterogeneity in experience and perceptions.

Challenges in developing and using experientially based measures

Processes for collecting in-depth information and developing measures

As discussed in the previous section, one challenge to the use of the US approach in developing countries is how to collect in-depth information and use the resulting understanding to create valid measures of food security in a simple and feasible way. Combining some in-depth interviewing with quicker RRA methods might help, although RRA exercises can be time-consuming for local people.

One potential process for obtaining understanding and developing measures has been suggested [17]. First, in-depth interviews and focus groups are used to identify locally defined food-secure and food-insecure households and understand food-related activities and other issues, such as management strategies in good and bad years. This information is then used by project staff and villagers to identify indicators for monitoring the general food-security situation and for showing when food security is worsening in different households. From these, specific indicators that can measure the impact of project activities on food security are selected. This process appears well conceptualized and has been well received in the field. Field testing has been limited, however, and has not been fully carried out because local staff have been overcommitted with other duties and there has been a lack of perceived importance of the process by project management [Aune J, personal communication, 1999].

Davies [22] also presents a methodology for such a process and notes that, although feasibility remains an issue, high-quality information about access to food can be reasonably and cost-effectively collected by well-trained local field researchers tapping indigenous sources of information. Maxwell's [6, 7] approach of combining interviews, focus groups, and questionnaires is relatively quick and low cost, taking only a couple of days to use local knowledge to adjust apparently universal categories to be location specific [Maxwell D, personal communication, 1999]. Finally, the rapid method for analysis of largely open-ended interviews developed by Phillips and Taylor [21] might be a model for speeding up analysis.

These examples suggest that simple and feasible data collection and analysis are possible. Further field testing and evaluation of potentially useful processes are needed so that a practical process for widespread use can be developed.

Ensuring validity of measures

A good measure needs to be relevant, credible, low-cost, time sensitive, and appropriate for the decisions that need to be made [23]. It also usually needs to be comparable across locations. Although some aspects of the experience of food insecurity are probably reasonably universal across locations and cultures, the experience is likely to be locally specific in many aspects. It is not known whether assessment tools that are experientially based will need to be so location specific that comparability (and aggregation) will be limited.

The US Food Security Measure is understood to be broadly comparable across the United States, although this has not been examined sufficiently. This comparability will probably hold in many other countries as well, but may not in some.

An important aspect of developing a new measure is ensuring that it is valid. This requires the availability of criterion measures for comparison. Most attempts to evaluate the validity of food-security measures have used determinants or consequences, such as economic resources, dietary intake, or nutritional status, as criterion measures (fig. 1). These measures, however, are usually not more definitive or accurate than the measures of food security being tested. Associations between these criterion measures and measures of food security are often found to be weak; these associations are then inconclusive as to whether it is the developed measure, the criterion, or both that inaccurately reflect food insecurity.

Accuracy (i.e., lack of bias) is best assessed by comparison to a definitive criterion, one that achieves high accuracy by relying on first principles, i.e., by reflecting in a fundamental way the theoretical structure of the phenomena it purports to represent [8]. An important challenge is obtaining definitive criterion measures so that validation efforts will be conclusive. One way to develop a definitive measure is to base it on information gained from an in-depth understanding of the experience itself through a personal interview with the respondent, and to use expert judgment to integrate this information to classify households as to food-security status. This method was used in assessing the validity of food-security measures in the US and Canada [9, 10, 24].

Form of measures

Another important issue is what form a measure should take. This depends on the information needed and the purposes and decisions for which it will be used. For example, for planning and designing interventions, a qualitative assessment of food security may be adequate, whereas for monitoring and assessing food aid needs, a quantitative measure is probably needed. The US measure and quantitative scale indicating levels of severity were appropriate to the information needs in the United States, but they might not be appropriate elsewhere. In some cases, multiple measures might be needed to effectively capture the multiple dimensions to the problem of food security or to support the information needs of different program approaches [23]. It may also be important that the form of the measure allow assessments to be timed according to the volatility of the food situation and the appropriate seasons.

Application issues

In developing countries, the food situation is often volatile. It is important to measure not only the current situation, but also the uncertainty of the future situation (i.e., vulnerability) and to assess changes in risk status over time, taking account of the choices households make to allocate their resources over time in ways that try to balance ensuring current access without jeopardizing future food consumption.

An important challenge to directly assessing household food security by asking people about their experience is possible intentional bias in reporting due to self-interest. That is, respondents may answer untruthfully to gain food or other assistance. This is a problem in some developing countries, such as Mozambique [Rose D, personal communication, 1999]. The opposite challenge may also occur if people are reluctant to express the deprivation that they experience because of embarrassment. The research underlying the development of the US Food Security Measure found that it was possible largely to avoid such reporting bias through careful construction of questionnaire items.

There are a number of other issues regarding the potential portability of the US approach to measuring household food security in developing countries [25]. One is that food insecurity may be defined differently in developing countries than in the United States, where it is typically much less severe and is a social as well as a biological matter. Another is that experientially based measures should be used to complement rather than replace indirect measures, since these often describe reasons for food insecurity and increase the use and value of regularly collected statistics. Finally, research is needed to determine whether there are fundamental constraints to applying the US approach where immediacy, prevalence, and severity of prolonged food deprivation is high.

Summary and recommendations

There is no simple formula for constructing valid measures of food security. From research to date, however, the approach of developing measures based on an in-depth understanding of the experience of food insecurity has great potential. This approach involves obtaining an in-depth understanding and turning this understanding into a measure from which an indicator can be chosen. The measure and indicators need to be validated, ideally against definitive measures.

The application of this approach requires the following:

» Construct and validate measures of food insecurity based on people's experience, using both qualitative and quantitative methods in a variety of locations;
» Based on this research, develop a practical protocol that can be feasibly applied in a wide variety of locations to facilitate construction of appropriate experientially based measures of food insecurity;
» Disseminate the results and the protocol, and promote their appropriate use.

Additional objectives include understanding the following:

» What methods are most useful and feasible for obtaining in-depth understanding of food insecurity,
» Which aspects of food security are universal and which are specific across locations and cultures,
» How to develop definitive measures for assessing validity,
» How to construct measures that minimize self-interest bias,
» In what circumstances a quantitative scale can be constructed indicating levels of severity,
» Rules for classifying households to create indicators from the measures,
» How to construct measures to monitor changes in individual households over time,
» In what circumstances multiple measures are needed to capture the multiple dimensions of food security.

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Impact of providing a small income on women's nutritional status and household food expenditures in rural Nepal

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Abstract

This study evaluated the impact of providing a small income on the household food expenditures and nutritional status of women employed part-time in a health project. A prospective, nonrandomized, unmasked, controlled trial was conducted in Sarlahi District in rural southeastern Nepal. The study subjects were 870 women who applied for a job with a project distributing nutritional supplements in their villages. Of these women, 736 (85%) completed the two-year follow-up; 341 were hired for the job and 395 were not hired. The intervention consisted of part-time employment that provided a small income, and the outcome was the two-year change in mid-upper-arm circumference (MUAC) and household food expenditures after adjustment for baseline demographic and socioeconomic differences. The women who were hired were younger and better educated than those who were not hired, but in other respects the two groups of women were similar. After adjustment for these baseline differences, the change in MUAC was not significantly different between the two groups of women. The two groups of women also had similar two-year changes in total household food expenditures and in expenditures on meat, clarified butter, fish, eggs, milk, and vegetables. There was a decline in the proportion of households buying milk and ghee, and the decline was significantly smaller in the households of women who were hired. Although employment by the project did not appear to affect the nutritional status of the women or change their overall expenditure on food, households of women who were hired were more likely to be able to continue to buy certain higher-status foods that could have a nutritional benefit for other household members.

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Introduction

Alleviation of poverty by micro-credit or small-scale employment is increasingly seen as a method to improve general family welfare, health, and nutrition [1–4]. Many of these programs are aimed at women, because it is hypothesized that targeting women would have greater impact on family health and nutrition than programs that generate income for men [5–7]. The success of the Grameen Bank of Bangladesh has been well documented in terms of income generation and loan repayments, but there are few data to support the impact of such programs on health and nutrition [8–12].

We report here the results of an evaluation of the impact of providing a modest but steady income from part-time employment over a period of two years to rural women in Sarlahi District, Nepal. The study was part of a larger randomized, placebo-controlled community trial assessing the impact of providing a small weekly dose of vitamin A or β-carotene to women of childbearing age on fetal wastage, maternal mortality, congenital malformations, and early infant mortality, morbidity, and growth [13]. Approximately 45,000 women were enrolled in the trial, which started in 1993. Because of the potential teratogenicity of large doses of vitamin A, the vitamin had to be provided as small weekly doses. The only feasible way to deliver such an intervention was to employ a large number of village-based women who would provide the vitamin to eligible women in their communities. The employment was offered on a part-time basis, because the many household responsibilities of these women would have made full-time employment difficult. Since several hundred women were needed, the study provided a unique opportunity to examine the economic, social, and health impacts of a small income by comparing women who received an income from employment in our project with other women who applied for the job but were not hired.

Materials and methods

The design of the study was prospective. Women were followed over time to assess the impact of employment on changes in household food expenditure and mid-upper-arm circumference (MUAC). The women enrolled in the study had applied for part-time employment distributing weekly supplements to married women of childbearing age in their own or neighboring communities. The job involved weekly visits to the homes of about 100 women to provide supplements, note the occurrences of menses in the previous week, record pregnancy status (not pregnant, pregnant, miscarriage in the previous week, stillbirth in the previous week, or live birth in the previous week), and record the receipt of supplements. The women received about 900 Nepalese rupees (US$15) per month for an estimated five hours of work per week.

The study was explained to all job applicants, and they were asked if they would be willing to complete a questionnaire at that time and two and five years later, regardless of whether they were selected for employment. The baseline questionnaire was administered by project staff who were not involved in interviewing and selecting the employees. Selection of employees was based on the results of a reading and writing test, relevant work experience, and an interview.

In the baseline interview, demographic and socioeconomic characteristics of the women and their households were recorded, such as age, literacy, caste, and ownership of land and animals. The usual weekly household expenditures were ascertained for all food, as well as for specific foods such as meat, clarified butter (ghee), fish, eggs, milk, and vegetables. The MUAC of all applicants was measured with an insertion tape [14].

Baseline questionnaires were administered during the job application and interview process from December 1992 through January 1993. Two years later, we attempted to re-interview all women who had completed the original questionnaire. The follow-up questionnaire asked the same questions about demographic and socioeconomic features. Household food expenditure was ascertained and MUAC was measured in the same manner as at baseline.

Baseline comparisons between those selected and not selected for employment were performed item-by-item by using a *t*-test for continuous data (after transformation for data not normally distributed) or a chi-square test for categorical data. Variables were selected for inclusion in a logistic regression model with employment status as the outcome, based on item-specific comparisons that reached statistical significance at the 5% level.

To assess the impact of employment, changes in expenditure and in MUAC were compared in employees and nonemployees. For changes in food expenditure and MUAC, linear regression was used to assess the effect of employment, adjusted for baseline differences associated with selection for employment. This was done by fitting a model with MUAC as the outcome and covariates that included those found to be significantly predictive of which women were selected for employment from the previously described logistic regression. The difference in MUAC between employees and nonemployees was obtained by including an indicator of employment as a covariate. For binary outcomes, such as whether the household bought the specific foods, logistic regression was used to assess the impact of employment by modeling the binary outcome at two years as a function of employment status, the binary outcome at baseline, and the baseline covariates associated with selection of employees. The data are presented as adjusted mean changes in expenditures, or as adjusted odds ratios for the primary outcomes.

The women gave oral informed consent to participation in the study. Ethical approval for the study was given by the Joint Committee on Clinical Investigation of the Johns Hopkins School of Medicine and by the Nepal Health Research Council.

Results

A total of 870 applicants completed the study questionnaire before employees were selected. Of these, 350 were hired and 520 were not hired. Two years later, 7 of the 350 who had been hired were no longer employed by the project; 3 of these completed the questionnaire and 4 refused. Two employees could not be interviewed because they were on leaves of absence from the project area for more than two months. Of the 520 women who had been hired, 2 were dead, 2 had been hired to replace women who were no longer employed, 85 had been away from the project area for more than two months and their whereabouts were unknown, and 36 were not at the addresses given two years before. Therefore, we compared the 341 women who had originally been hired and who had been continuously employed by the project for two years with the 395 women who had never been hired and who completed follow-up questionnaires.

Baseline comparisons

The women who were hired were significantly younger than those who were not (25.2 vs 28.9 years)(table 1). They were also more likely to be literate (98.2% vs 81.7%; odds ratio, 10.8; 95% confidence interval, 4.9 to 28.2), to have 10 or more years of formal schooling (23.2% vs 13.2%; odds ratio, 2.0; 95% confidence interval, 1.3 to 3.0), and to have household servants

TABLE 1. Baseline age, mid-upper-arm circumference (MUAC), and literacy of women employed and not employed by the project

	Employed (n = 341)		Not employed (n = 395)	
Characteristic	No.	%	No.	%
Age (yr)				
< 20	36	10.6	19	4.8
20–29	232	68.4	192	48.7
30–39	58	17.1	140	35.5
40–49	12	3.5	37	9.4
≥50	1	0.3	6	1.5
Mean ± SD	25.2 ± 6.2		28.9 ± 7.7	
MUAC (cm)				
< 21.0	53	15.7	60	15.3
21.0–22.9	131	38.8	148	37.6
23.0–24.9	110	32.6	117	29.7
> 25.0	44	13.0	69	17.5
Mean ± SD	22.8 ± 2.0		23.0 ± 2.2	
Literacy	334	98.2	322	81.7

(35.4% vs 21.1%; odds ratio, 2.0; 95% confidence interval, 1.5 to 2.9). They were less likely to smoke (2.4% vs 12.4%; odds ratio, 0.54; 95% confidence interval, 0.36 to 0.80) and to spend more than four hours per week fetching firewood (14.9% vs 24.8%; odds ratio, 0.17; 95% confidence interval, 0.07 to 0.38). Those who were hired and those who were not hired were comparable with respect to caste, household size, and ownership of animals and other household goods such as radios, watches, bicycles, and furniture.

The distribution of MUAC was comparable in the two groups of women (p = .40). MUAC was less than 21 cm in 15% of women in both groups. The average MUAC was 22.8 cm among those who were hired and 23.0 cm among those who were not (p = .48)(table 1).

More than 95% of households had spent money on food in the previous week, but less than two-thirds had bought meat, ghee, fish, eggs, or milk (table 2). Households of women who were hired were more likely to have bought ghee in the previous week than households of women who were not hired (46.6% vs. 39.2%; odds ratio, 1.4; 95% confidence interval, 1.0 to 1.8). However, after adjustment for baseline differences between the two groups of women, the difference between the two groups was not significant. Among those households buying specific foods, the expenditure on each item was comparable for households of women who were hired and households of women who were not hired (table 3). On the average, households of women who were hired spent 255 rupees per week on food, as compared with 273 rupees by households of women who were not hired.

In a logistic regression model with employment status as the outcome, women who were hired were significantly younger, were more likely to be literate, were less likely to be smokers, spent less time fetching firewood each week, and were more likely to have household servants (table 4). These significant baseline factors were used to adjust all the follow-up comparisons between the two groups of women.

TABLE 2. Number and percentage of households of women employed and not employed by the project that bought specific types of food in the previous week at baseline

	Employed (n = 341)		Not employed (n = 395)	
Food Type	No.	%	No.	%
Any food	324	95.3	368	93.2
Meat	210	61.6	252	63.8
Ghee	159	46.6	155	39.2
Fish	138	40.5	157	39.7
Eggs	86	25.2	98	24.8
Milk	175	51.3	177	44.8
Vegetables	309	90.6	365	92.4

TABLE 3. Baseline expenditures (Nepalese rupees) for specific types of food in the previous week by households of women employed and not employed by the project

	Employed (n = 341)		Not employed (n = 395)	
Food Type	Mean ± SD	Median	Mean ± SD	Median
All food	255 ± 220	200	273 ± 214	200
Meat[a]	95 ± 70	80	95 ± 73	80
Ghee[a]	69 ± 59	50	59 ± 43	50
Fish[a]	63 ± 59	50	59 ± 38	50
Eggs[a]	30 ± 61	20	28 ± 26	20
Milk[a]	54 ± 46	41	58 ± 54	50
Vegetables[a]	52 ± 48	50	51 ± 55	40

a. The means and medians are based on data from those households that bought the specific type of food.

TABLE 4. Logistic regression results showing baseline factors that predicted employment by the project

Variable	Odds ratio	95% confidence interval
Age (yr)	0.95	0.92–0.97
Literacy	8.07	3.33–19.56
No. of household servants		
1	1.55	1.04–2.32
>1	2.89	1.53–5.45
Smoking	0.38	0.16–0.90
> 4 h/wk spent fetching wood	0.64	0.42–0.98

Changes from baseline through two years of follow-up

At follow-up, 36 of the 395 women who had not been employed by the nutrition project (9.1%) reported that they had been employed in jobs for which they were paid some cash. Among the 341 women who had been employed by the project, 106 (31.1%) reported additional cash employment (the project employment was part-time). However, the amount of cash payments associated with these additional activities was not determined.

After adjustment for the baseline differences listed above, there were no differences between women who had and had not been employed by the project in the changes in MUAC (means, –0.20 and –0.25 cm, respectively; $p = .67$)(table 5).

TABLE 5. Distribution of changes in mid-upper-arm circumference (MUAC) of women employed and not employed by the project from baseline to two-year follow-up

	Employed ($n = 335$)[a]		Not employed ($n = 383$)[a]	
Variable	No.	%	No.	%
Change in MUAC (cm)				
>–2.0	35	10.4	41	10.7
–2.0 to <–1.0	47	14.0	59	15.4
–1.0 to <0.0	99	29.6	100	26.1
0.0 to <1.0	101	30.1	116	30.3
1.0 to < 2.0	34	10.1	50	13.1
≥ 2.0	19	5.7	17	4.4
Adjusted mean change (cm)[b]	–0.20		–0.25	

a. Based on subjects for whom data were available.
b. Adjusted for baseline age, literacy, number of household servants, smoking, and hours spent fetching firewood.

The proportion of households buying meat, ghee, fish, eggs, milk, and vegetables was slightly higher among households of women employed by the project, and this difference remained significant after adjustment for baseline differences (table 6). The households of employed women were significantly more likely to buy ghee (odds ratio, 1.42; 95% confidence interval, 1.00 to 2.03) and milk (odds ratio, 1.45; 95% confidence interval, 1.03 to 2.04).

The total expenditure on food increased in both groups, although there was no real increase after adjustment for inflation in rupees (table 7). The expenditures on ghee, fish, eggs, and milk declined slightly, implying a real decrease after adjustment for inflation. However, there were no significant differences between the two groups of women in the changes in expenditures from baseline to follow-up.

Discussion

This study examined the impact on nutritional status and household food expenditure of providing a small income for women over a period of two years. We found no effect on changes in total expenditure on food or on expenditure for specific types of higher-status foods, such as those with higher contents of fat and animal protein. However, we did find that, although the proportion of households that bought ghee and milk declined over the two-year period, the decline was significantly lower among households of women who had been employed by the project. Other studies have shown that extra income is used to buy higher-status or higher-quality foods, such as meat, fish, milk, or eggs [15, 16]. In our study, the income from employment appears to have protected households from ceasing to purchase these products.

TABLE 6. Number and percentage of households of women employed and not employed by the project that bought specific types of food in the previous week at two-year follow-up

	Employed ($n = 341$)[a]		Not employed ($n = 395$)[a]			
Food type	No.	%	No.	%	Adjusted OR[a]	95% confidence interval
Any food	331	97.1	370	93.7	—[b]	—[b]
Meat	174	51.0	193	48.9	1.17	0.84–1.62
Ghee	109	32.0	88	22.3	1.42	1.00–2.03
Fish	66	19.4	68	17.2	1.21	0.79–1.85
Eggs	51	15.0	48	12.2	1.05	0.66–1.67
Milk	153	44.9	137	34.7	1.45	1.03–2.04
Vegetables	325	95.3	371	93.9	1.20	0.51–2.82

a. Adjusted for baseline age, literacy, number of household servants, smoking, hours spent fetching firewood, and whether the specific food type was bought at baseline.
b. No odds ratio could be estimated for this category because there were very few households that bought no food.

TABLE 7. Adjusted mean change in weekly food expenditures (Nepalese rupees) by households of women employed and not employed by the project from baseline to two-year follow-up

Food type	Adjusted mean change		Adjusted difference	95% confidence interval
	Employed ($n = 341$)	Not employed ($n = 395$)		
Any food	126.9	149.4	–22.5	–69.4 to 23.5
Meat	1.6	0.6	1.0	–15.4 to 17.3
Ghee	–5.8	–6.2	0.4	–9.9 to 10.6
Fish	–13.0	–13.7	0.7	–7.0 to 8.4
Eggs	–3.8	–4.2	0.4	–4.0 to 4.7
Milk	–1.3	–2.4	1.1	–10.0 to 12.2
Vegetables	16.4	17.1	–0.7	–11.5 to 10.2

a. Adjusted for baseline age, literacy, number of household servants, smoking, hours spent fetching firewood, and expenditure on the specific food type.

There appeared to be no effect of employment on the nutritional status of women, as shown by MUAC. It is possible that there were changes in other anthropometric indicators, but these were not measured. In addition, although subtle changes in the purchase of certain foods could be seen, they occurred at the household level, and the type and quantity of food allocated to different household members may vary in this environment. Hence it is possible that greater access to certain types of foods translates into improved nutritional status for other household members, but the nutritional status of others in the household was not measured.

Another difficulty with such studies is that expenditure does not necessarily translate into consumption, because many foods are grown or raised within the household and are unlikely to be purchased. Although consumption was not assessed, there were no baseline differences, and there was no effect of employment on ownership of animals or land. There were also no differences in the size of the households that might lead to differences in per capita expenditure on food.

Another explanation for the lack of impact of employment on nutritional status and on expenditures for some of the higher-status foods may be that women who applied for this job were better educated and came from higher socioeconomic backgrounds than the general population of Sarlahi. The overall literacy rate among women of childbearing age in Sarlahi is 12%, whereas the rate was 98% among women employed by the project and 82% among those who were not employed. Similarly, a higher proportion of these women came from Brahmin households that owned more land, animals, and household goods than the average household [17, 18]. Furthermore, 15% of these women had an MUAC less than 21 cm, compared with 27% of the general population of women (excluding those with night-blindness) in Sarlahi [19]. According to the questionnaires, women who were employed by the project were more likely to buy gold jewelry (a form of personal savings in this setting) than those who were not employed. They also reported higher expenditures on items for children, such as clothing and education. It may be that there is little perceived need to use this income to increase the amount or quality of food in the household. However, although these women were not the poorest of the poor in Sarlahi, they would still be considered poor, with 20% coming from households that owned no land in a subsistence farming environment.

This study suggests that the effect of employment or other income-generating activities among the rural poor cannot be assumed to translate automatically into increased household expenditures on food. Many other competing demands for cash income may supersede increases in expenditures for food, especially in poor households, but not among the poorest of the poor. In this population, there was evidence that the proportion of households buying higher-status foods declined during the two years of follow-up. However, this decline was similar for households of employed and unemployed women, except for the purchase of milk and ghee. Therefore, employment appeared to protect families from ceasing to purchase higher-status foods in an environment in which economic pressures during the study period were reducing such purchases among those who were not employed. In this sense, employment did have an impact on the purchase of animal sources of protein and fat in the household diet.

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Iraqi national survey data on malnutrition and breastfeeding practices among children under five years of age

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Abstract

In a national nutrition survey conducted in Iraq during 1992 to 1994, anthropometric measurements were obtained from 3,616 children under five years of age. Wasting was found in 10.8% and stunting in 21%. The nutritional status of children was worse in southern Iraq than in Baghdad. Although classical nutritional diseases disappeared from the country many years ago, the survey found signs of marasmus in 17.5% of the children and kwashiorkor in 0.3%. Iodine-deficiency disorders and anemia were also public health problems. Information on infant feeding practices was gained from mothers by direct interview. Wasting was much more frequent among formula-fed children than among breastfed children (49.3% vs 28.9%, p < .01*). Less than 60% of the latter were exclusively breastfed during the first four months of life. Iraqi women are in great need of breastfeeding-promotion programs. Well-planned health and nutritional intervention programs for children under five years of age are also essential.*

Introduction

The 44,839-km^2 area of Iraq makes it one of the largest Arab Gulf countries. Its estimated total population is 22.7 million, of which 42% is under 14 years old. The population is mainly urban (71%) and has an annual growth rate of 2.7%. Up to 1990 there were very significant advances in the provision of health care, and infant mortality had declined to about 40 per 1,000 live births. The situation deteriorated dramatically after the embargo began in 1990, and the country currently faces severe shortages of food and medicine and exceptionally high food prices. In a national nutrition survey conducted in Iraq from 1992 to 1994, anthropometric measurements were obtained from 3,616 children under five years old. The relationship between infant-feeding practices and nutritional status in Iraqi children was also investigated.

Materials and methods

The research design used has been described previously [1]. The sample consisted of 3,616 infants and young children under five years of age (most were between zero and 24 months old), of which 52% were male and 48% were female. Their age distribution is given in table 1. The subjects were children attending the maternal and child health centers in 11 of 18 Iraqi governorates. The other seven governorates were excluded because of the difficulties of transportation in three of them and because of the low population density in the other four.

The standing height (without shoes) was measured for children 24 months of age or over, and the supine length of children under 24 months old was measured to the nearest 0.1 cm. Boards and scales were checked periodically to insure their accuracy. One specially trained assistant was solely concerned with recording height or length and another with measuring weight. The scales were calibrated daily, and standardization was rechecked at the completion of the fieldwork. The anthropometric measurements were taken in a

TABLE 1. Age distribution of the study population ($n = 3{,}616$)

Age (mo)	%
0–5	25.24
6–11	33.07
12–23	22.15
24–35	9.92
≥36	9.59

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standard manner, as recommended by the Centers for Disease Control [2]. Salter portable baby scales were used to measure body weight to the nearest 50 g with little clothing.

All infants and children underwent a full physical examination. The diagnostic criteria for kwashiorkor were based on the Wellcome classification [3], which depends on the body weight and height deficit and the presence of edema. Edema was determined by firm thumb pressure for three seconds on the dorsal surface of the feet. The liver was considered to be enlarged when its edge was more than a finger's breadth below the costal margin.

Clinical vitamin A deficiency was determined by using the World Health Organization international classification [4]. Only clearly evident signs of vitamin A deficiency were recorded. Laboratory determinations of hemoglobin concentration were made for every third child in Baghdad City, using the cyanmethemoglobin method (Drabkin), with a Lumetron model 400A instrument. Anemia was considered to be present when hemoglobin levels were below 11 g/dl in children aged six months to five years [5].

The anthropometric indicators used to identify protein–energy malnutrition were weight-for-height, weight-for-age, and height-for-age *Z* scores. At the time of the initial examination, age to the nearest month was obtained from birth certificates. Anthropometric data were compared with the National Center for Health Statistics/Centers for Disease Control (NCHS/CDC) reference standards [2]. Children were considered wasted if their weight-for-height was below –2 SD *Z* scores, stunted if their height-for-age was below –2 SD *Z* scores, and underweight if their weight-for-age was –2 SD *Z* scores [6]. The Gomez classification was used to assess the degree of malnutrition [7].

Information on infant feeding was gained from mothers by detailed interviews. The age when breastfeeding completely stopped was recorded to the nearest month. By definition, exclusively breastfed infants did not take solids or milk other than human milk before the age of four months. Formula feeders received formula from birth and were introduced to solid foods at four months. The sample consisted of 1,451 exclusively breastfed and 2,162 formula-fed children; data on feeding practices for 3 children were not available.

Results

The prevalence of wasting and stunting in different governorates is shown in table 2. Wasting was more prevalent in the southern regions (15.4% in Al-Aumara, 18.7% in Wasit, 20.3% in Basrah, and 20.7% in Theqar ($p \leq .05$). The prevalence of stunting ranged from 10.6% to 27.0%. The highest prevalences of stunting were observed in Kerbala (20.8%), Wasit (24.3%), and Al-Aumara (27.0%).

The prevalence of wasting and stunting according to age group is shown in table 3. Wasting was highest between 6 and 11 months and remained high until after 35 months of age. The prevalence of stunting was highest between 24 and 59 months of age. Moderate to severe malnutrition, by the classic Gomez classification, was observed in about 30% of children from 12 to 35 months and in about 20% of those under 12 months and over 36 months.

The prevalence of various clinical signs according to age is summarized in table 4. Marasmus and marasmic kwashiorkor were highly prevalent. Of the 466 children in Baghdad surveyed for hemoglobin, 39.8% had hemoglobin values less than 11 g/dl (table 5). Thus more than one-third of the children examined were anemic, with the highest prevalence in the 24- to 35-month age group.

The mean weights at birth for both sexes and for all children were similar, averaging 3,120 g for girls and 3,211 g for boys. The mean birth lengths were 49.1 cm for girls and 51.0 cm for boys. The proportions of children with different cutoff points of anthropometric

TABLE 2. Prevalence of wasting and stunting according to governorate ($n = 3,616$)

Governorate	Wasting (%)	Stunting (%)
Baghdad	1.1	10.6
Dialah	4.3	14.3
Al-Anbar	2.1	18.9
Wasit	18.7	24.3
Al-Aumara	15.4	27.0
Babil	10.2	19.8
Kerbala	9.3	20.8
Mousel	5.2	15.3
Basrah	20.3	18.7
Al-Quidisia	12.4	19.6
Theqar	20.7	15.1

TABLE 3. Prevalence of wasting and stunting according to age

Age (mo)	Wasted[a] (%)	Stunted[a] (%)	% moderate to severe malnutrition[b]
0–5	3.6	3.2	18.6
6–11	23.9	10.1	19.7
12–23	18.0	16.3	30.5
24–35	17.7	38.9	32.5
36–47	5.1	31.6	20.6
48–59	6.5	26.1	18.5
0–59	10.8	21.0	21.8

a. Waterlow classification [6]
b. Gomez weight/age classification [7]

TABLE 4. Prevalence of clinical signs of nutritional deficiency

Sign	Prevalence (%)
Marasmus	17.5
Kwashiorkor	0.3
Marasmic kwashiorkor	17.8
Enlarged liver	3.5
Iodine-deficiency disorders (enlarged thyroid)	20.4
Xerosis	0.1
Bitot's spots	0.3
Angular lesions and scars	0.4
Papillary atrophy of tongue	1.5
Cheilosis	6.9
Nasolabial seborrhea	2.6
Swelling of tongue	3.4
Acute respiratory infection	3.6
Diarrhea	2.4

indicators are shown in table 6 according to their feeding practices. Formula-fed children were more likely to be malnourished than exclusively breastfed children (8.4% vs 5.7%, $p < .05$). Wasting (weight-for-height < –2 SD scores) and stunting (height-for-age < –2 scores) were less prevalent among exclusively breastfed children (2.5% vs 8.3%, $p < .01$; 5.1% vs 10.2%, $p < .05$, respectively).

Discussion

Increasing attention has been paid recently to malnutrition in Iraq, which is now recognized to be more common in many parts of the country [8–11]. In 1996 we reported that 21.8% of the population under five years old was malnourished, with weight-for-age less than –2 SD of the reference [1]. Malnutrition is considered to result from a set of factors, such as poverty, ignorance, feeding practices, and lack of appropriate supplementary foods [12, 13]. When infants are exclusively breastfed from birth through four to six months, malnutrition is rare [14].

Almost 10.8% of the children were wasted. Because this is the first national nutrition survey in Iraq, the results of this study cannot be compared with earlier national data. However, the prevalence of wasting in this study is higher than that reported in a 1991 survey in Baghdad [10] and that reported by Al-Doori et al. [11]. In the latter study, 8% of the children surveyed in Basra City were wasted. In a UNICEF assessment of the nutritional status of children in the Al-Muthana governorate (adjacent to Wasit), 10.3% of the children exhibited wasting, most of whom were under six months of age. According to the Gomez classification, over one-fifth of the children were moderately to severely malnourished.

TABLE 5. Hemoglobin values of children in Baghdad

Age (mo)	% of children with hemoglobin value		
	< 11.0 g/dl	11.0–11.9 g/dl	≥ 12.0 g/dl
0–5	22	29	5
6–11	31	38	22
12–23	46	53	24
24–35	55	49	20
36–47	47	44	19
48–60	38	41	17
All ages	39.8	42.3	17.8

TABLE 6. Proportion of children with different cutoff points of anthropometric indicators according to feeding practices

Cutoff point (SD *Z* score)	Exclusively breastfed (%)	Formula-fed (%)
Weight-for age		
<–3	2.3	5.4**
<–2	5.7	8.4*
>–2	49.3	28.9*
Height-for-age		
<–3	1.9	3.8*
<–2	5.1	10.2*
>–2	0.8	38.2 NS[a]
Weight-for-height		
<–2	2.5	8.3**
>–2	54.2	35.0**

a. NS, Not significant. * $p < .05$; ** $p < .01$.

Neither marasmus nor kwashiorkor had occurred in Iraq for many years [15]. However, our results show that these severe nutritional deficiencies have returned to Iraq. A 1995 mission of the Food and Agriculture Organization reported that both marasmus and kwashiorkor were widely observed in pediatric wards throughout the country [16]. A Harvard study team [17] attributed the severe cases of malnutrition to the epidemic levels of water-borne diseases. Moreover, sanctions have led to an increase in food market prices beyond the means of most families [18].

A more recent survey of the prevalence of iodine deficiency in Iraq found that at least 50.8% of the people are now affected [19]. The prevalence data in our study are based on clinical assessment of thyroid enlargement (20.4%). The 39.8% prevalence of anemia among children under five in all parts of Baghdad is an important problem. Clinical signs of deficiencies of B vitamins and vitamin A were observed in a small number of children and were not regarded as a public health problem. However, in 1992 UNICEF carried out a survey in southern Iraq that found both nutritional anemia and vitamin A deficiencies to be prevalent

[18]. All of the evidence indicates that effective nutrition and health intervention programs for children under five years of age and breastfeeding promotion are urgently needed.

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Household structure and dietary patterns in the Afro-Ecuadorian highlands

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Abstract

Dietary patterns in contemporary societies have been a primary focus of nutritional and anthropological research. Class, occupation, income, and gender have been studied when analyzing dietary patterns and the roots of malnutrition and hunger; however, the effects of household structure have received less attention. The main purpose of our study was to obtain information on the diet of a highland Afro-Ecuadorian community and examine the relationship between household structure and dietary patterns. Survey questionnaires, in-depth questionnaires, and participant observation were utilized to examine how women in female-headed households compare with women in male-headed households in meeting the dietary needs of their families. There was no significant difference in food-acquisition patterns. Weekly expenditures for food in the two types of households were similar, despite different income levels. However, female-headed households had higher food-group scores and consumed more meals per day.

Introduction

Dietary patterns in contemporary societies have been a primary focus of nutritional and anthropological research. A substantial portion of this research has been directed at the relationship between changes in diet and health, with specific attention paid to child growth and development, nutrition-related diseases, and nutrient intake [1–8]. When discussing variation in dietary patterns, researchers have long paid attention to the divisions of class, gender, occupation, income, and education. Recently, researchers have begun to investigate the effects of household structure and intrafamily inequalities.

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Since the mid-1970s, the number of women-headed households has been increasing in both industrialized and developing countries. The concept of head of the household was originally introduced into census and survey research in order to reduce double counting of household members. However, researchers have recently assigned greater meaning to the term, associating it with authority, economic responsibility, and power within the household. Since as far back as 1978, definitions of household headship have varied [1]. Researchers have suggested that the convention "female-headed household" (i.e., a household without an adult male) is too limiting [9, 10]. More recent definitions of headship are emerging in which researchers and policy analysts try to account for differences in household structure that are the result of contemporary demographic and social changes. Currently, most researchers agree that female-headed households in today's world are not a homogeneous entity.

Despite the difficulty in defining household headship, it is commonly accepted that female-headed households tend to be poorer than male-headed households or less likely to be helped by typical economic development policies. When female-headed households occur in the context of societies where male-headed households or dual headship of households are the cultural norm, several factors contribute to the higher probability of poverty in female-headed households. First, although they tend to be smaller, female-centered households often have a higher dependency ratio (the number of individuals not contributing to household welfare compared with the number who are contributing); second, the average earnings of adult females tend to be lower than those of males; and third, many women have time constraints related to child care and home responsibilities, thus decreasing their wage-earning power. Consequently, there is a growing concern over the health and nutritional status of members of female-centered households [9–15].

In this paper we discuss dietary patterns in a population of African origin in Ecuador. Afro-Ecuadorian populations have been consistently marginalized in Ecuador by the government and the media. Similarly, scholars conducting research in the Ecuadorian highlands frequently fail to mention the presence of black populations in the area. Consequently, there are only a limited number of studies on the highland Afro-Ecuadorian population. In our anthropological and dietary study of highland Afro-Ecuadorians, we explored how women in both female-headed households and male-headed households cope with meeting the nutritional needs of their families. The aims of the project were both to provide general information on the diet of highland Afro-Ecuadorians and to examine the relationship between household structure and dietary patterns.

Methods

This study was conducted within the framework of a larger study that examined economic development and gender relations [16, 17]. We obtained information from survey questionnaires, in-depth questionnaires, and participant observation. Our ethnographic sample consisted of 48 households in the community of San Lucas. Demographic information, such as age, income, and occupation, was obtained by administration of the standard Ecuadorian census survey, to which we added questions pertinent to our study. Because the Ecuadorian government does not provide data on *caseríos* (towns), we surveyed the entire village, and complete census data were obtained from 114 of the 130 households that were occupied.

Because one of the objectives of the study was to explore the dietary patterns in female-headed households as well as male-headed households, we attempted to include all of the female-headed households in the study. During the demographic survey of the whole population, we determined that there were 21 female-headed households in the community. However, we were able to interview only 15 of those. Thirty-three male-headed households were selected randomly from a total of 93 in the village. Since there is substantial literature on the advantages and disadvantages of dietary research methods [1], we used several different methods. The dietary data for each household were obtained from the female head of each household through the use of a food-frequency questionnaire, a 24-hour recall interview that focused on household consumption, and a food-acquisition interview that was developed from ethnographic observations. The demographic characteristics of the sample are presented in tables 1 and 2.

We used Coronel's definition of female-headed household [18]. He combined definitions of female-headed households developed by Tanner [19] and González [20, 21] to understand the female-headed household pattern of San Lucas, and he established that a female-headed household cannot be defined in terms of the absence of a man, but only by the permanent presence of a woman as head of the household. A female-headed household is, therefore, a household in which the mother has sole control of the economic resources and decision-making responsibilities. Although this implies that no man has influence over the household, it is possible that even when not living in the household, a boyfriend or father of the children could influence its dynamics [18]. However, in this study we categorized female-headed households by the permanent presence of a female as the head of the household, regardless of any male influence.

Finally, we classified the food items into five food groups. Our classification system was based on the Ecuadorian food pyramid guidelines [22]. The guidelines utilize a pyramid which is divided into four nutri-

TABLE 1. Demographic and economic characteristics of the households

Characteristic	*n*	Mean	SD
No. of individuals[a]			
Female-headed households	15	4.2	2.18
Dual- or male-headed households	32	4.6	2.11
All households	47	4.4	2.11
No. of children			
Female-headed households	15	2.9	1.85
Dual- or male-headed households	33	2.7	2.01
All households	48	2.8	1.94
Monthly income[b] (sucres)[c]			
Female-headed households	6	263,500	145,291
Dual- or male-headed households	28	721,750	604,527
All households	34	640,882	577,623
Estimated weekly food expenses (sucres)			
Female-headed households	11	88,636	49,198
Dual- or male-headed households	25	96,920	69,256

a. Female-headed households: 7 single, 6 widowed, 1 divorced, 1 refused to answer. Dual- or male-headed households: 28 married, 3 widowed, 2 living together.
b. $p \leq .001$.
c. US$1.00 = 5,500 sucres.

TABLE 2. Comparison of age and years of education of the adult heads of households in the sample.

	All female heads			All male heads		
Characteristic	*n*	Mean	SD	*n*	Mean	SD
Age (yr)	41	44.0	17.16	33	47.2	14.31
Years of education[a]	44	3.5	2.54	27	5.0	2.28

a. $p \leq .05$.

ent categories: carbohydrates, vitamins and minerals, proteins, and fats and oils. These categories are then subdivided into the six sections of the pyramid, which are the same as the six food groups of the food pyramid developed by the US Department of Agriculture [23]: cereal and cereal products; animal products and other protein sources; dairy products; vegetables; fruits; and fats, oils, and sweets. Additionally, we categorized specific foods according to the guidelines presented in the *Guía Práctica de Nutrición* [22] so that foods such as potatoes, yucca, white carrots, and varieties of bananas are included in the cereal, grain, and pasta group rather than the fruit and vegetable groups, as would be found in the United States.

Study site and population

The Afro-Ecuadorian population is primarily concentrated in the province of Esmeraldas on the coast and in the highland valley of El Chota, 1,600 to 1,900 meters above sea level, in the province of Imbabura. However, many Afro-Ecuadorians also live in the provinces of Pichincha and Guayas. It has been difficult to determine the size of this population, because the national census is not broken down into racial categories. Santacruz [24], using the *Guía del Mundo* data, estimated the population as approximately 524,500, or 5% of the country's population [25]. At present, the urgent problems that need to be addressed for the Afro-Ecuadorian population include chronic unemployment and underemployment, lack of health professionals and centers, poor sanitation facilities, and high rates of malnutrition and maternal mortality [26].

The valley of El Chota is located in the northern highlands of Ecuador. Fifteen small towns (*caseríos*) dot the landscape, and the population is composed almost entirely of Afro-Ecuadorians and people of mixed descent. The people of the valley of El Chota are also known as "Andean" or "highland" blacks in order to distinguish them from the coastal Afro-Ecuadorian groups.

The present-day Afro-Ecuadorian population in the valley of El Chota are descendants of blacks who were brought to the highlands during the seventeenth century by the Jesuit Order Compañía de Jesús to work as slaves on their sugarcane plantations and properties [16]. When slavery was abolished in 1852 by President José María Urbina, the Afro-Ecuadorian population in the valley of El Chota remained on haciendas, working first in the debt peonage system known as *concertaje*. Later they worked on haciendas for four or five days a week in exchange for access to small plots of land, which they worked when they were not involved in hacienda-based agricultural tasks (a system termed *huasipungo)*, and finally as laborers. During an early agrarian reform, prior to the national Agrarian Reform of 1964, Afro-Ecuadorian families in the valley received plots of land from the haciendas [27].

Today the population of the valley of El Chota has an economy firmly established around the former hacienda system, with strong attachments to the land and to a lifestyle based on agriculture. Since not every family owns land, landless community members find employment through sharecropping; as wage laborers in sugar refineries, construction, and small-scale commercial activities; or in the service industry, as cooks or waiters in the nearby tourism zone.

Our study was conducted in San Lucas (a pseudonym given to the study community). This small town of approximately 130 households, with a population of 800 inhabitants, is located in the valley of El Chota. The community of San Lucas is neither harmonious nor homogeneous in terms of social stratification and economic status. Stratification in the community is based on three fundamental elements: access to economic resources, family configuration (i.e., household structure), and education. Male-headed households have higher status and greater acceptance than female-headed households. A household may be female-headed for various reasons: the woman had children with different men and none of the men take care of the family; the woman is the concubine of a married man from either the same or another town; the father of the family is deceased and the widow has not remarried; or the father has abandoned the household. In the female-headed households, women are in charge of the decision-making process, which confers upon them a feeling of security, despite the lower status that is often assigned to them.

Results

Household structure: Variations in household headship and dietary patterns

We focused our analysis on the relationship of household structure to dietary intake and food acquisition. Although female-headed and male-headed households varied significantly in terms of income, they did not vary in the educational level of adult females. Correlation analysis showed that the relationship of income level to household size was not significant; however, a substantial number of the female-headed households (7 of 13) did not provide information concerning their income. Five of these women indicated they did not know what their income was, primarily because it was so variable.

Food-acquisition patterns

The patterns of food acquisition and preparation described by the interviewees reflect the economic independence characteristic of highland Afro-Ecuadorian women. Money obtained from the economic activities of women was their own. In San Lucas women more often than men were responsible for purchasing the food that entered the household, and women were primarily responsible for managing the everyday household budget. Most food purchases were made in stores and markets located about 30 minutes from town, and travel was usually by motor vehicle, such as bus or taxi. Shoppers were more apt to use cash than credit, and there was no significant difference between household types in these patterns. Also, there was no significant difference between female-headed and male-headed households in estimated weekly food expenditures (table 1).

People also obtained food from their own agricultural lands or gardens, and a variety of vegetables and some fruits were grown. Sixty-three percent of the households either owned or had access to a garden. We found no significant difference between household types in the availability of a garden or the number of foods grown. A small number of households obtained food by gathering (14%) or hunting and fishing (6%). The traditional division of labor is evident in these practices, since only men engaged in hunting and fishing. Consequently, the female-headed households did not report obtaining food from these resources. Additionally, seven households (16%) indicated that they obtained money from the sale of wild foods, usually snails, which they gathered. Only a few households (7%), all of which were female-headed households, reported engaging in food exchange. Both types of households indicated that they received food gifts from relatives or friends. However, the total number of cases was low (19%, $n = 48$).

Food-intake pattern and dietary status

We used a food-frequency questionnaire and participant observation to obtain a general view of dietary practices and food-intake patterns of the sample. The food-frequency questionnaire contained 79 food items and was developed from ethnographic observation within the community. The food-intake pattern of the sample population was determined from the food-frequency interview and is presented in table 3, which depicts the types of food consumed on a daily, weekly, and monthly basis.

As is typical of Afro-Ecuadorians, nearly all San Luqueños (98%) ate steamed rice every day. Bread was also commonly consumed, usually during breakfast and at midafternoon as a snack with coffee. Noodles were eaten as a soup made with water, milk, onions, and potatoes. Green and ripe bananas (both fried as an accompaniment to a meal) were also commonly eaten.

Nonanimal sources of protein, such as beans and legumes, were eaten more commonly than meat products. The most commonly consumed meat products were chicken and eggs. Eggs, fried or prepared as omelettes (*tortillas*), were eaten daily by 46% of the sample. Pork, fried (*fritada*) and occasionally roasted, was the preferred meat during festivities. Cheese was consumed daily by 54% of the population, but the quantities eaten were very small. Usually one small piece of cheese was eaten with bread, or one piece of cheese was added to soup for the entire family. Milk was consumed by 21% of the population daily. It was usually added to coffee or soup and was rarely drunk by itself. *Café con leche* (caffé latte) was a delicacy regularly consumed by wealthier households.

The respondents did not consume a wide variety of vegetables every day. The respondents mentioned a total of 15 vegetables, with only onions, tomatoes, carrots, and bell peppers commonly eaten daily. These vegetables were added to soups or eaten as salads. Eleven fruits were named by respondents. Some of these fruits, such as mango, papaya, *tomate de árbol*, and orange, were usually made into juice and consumed at lunch.

A large number of the respondents reported drinking coffee or herb tea daily (79% and 67%, respectively). Alcoholic beverages, such as beer, *puro* (alcohol made from sugarcane), and rum, were also consumed throughout the month. *Puro* and beer were more commonly drunk on Sundays, during the regular weekly celebrations, whereas rum was drunk during special family or community festivities. Sugar was consumed by 100% of the population daily. Other sweets and snacks, such as potato chips, ice cream, and candy, were also consumed.

The majority of the respondents used vegetable oil for cooking; the second most commonly used fat was lard. The cooking method depended on the type of food. For example, deep frying was a common method for cooking meat, green and ripe bananas, and eggs. Soups were boiled. Vegetables were eaten raw unless they were added to soups, in which case they were also boiled. Fruits were also eaten raw or blended in juices. Beans and rice were steamed. Salt was consumed by 100% of the population daily. Condiments, such as annatto, cumin, pepper, and *sazonador* (a prepared condiment with a number of herbs and other spices), were commonly used to add flavor.

The data from the food-frequency questionnaires enabled us to compare consumption patterns between the two types of households. They were analyzed individually for each food item as well as in an aggregated format based on the food-group classification. The mean number of foods consumed from the food-frequency list was 53.85 different foods (minimum, 34; maximum, 66). No significant difference was found in the number of foods consumed in the two types of households. Similarly, no differences were found in the frequency of consumption (daily, weekly, or monthly) for the food groups. The data presented in table 3 show

TABLE 3. Number (percent) of households (*n* = 48) consuming various foods

Spanish name	English name	Period of consumption							
		Daily		Weekly		Monthly		Rarely or never	
		FH	D/MH	FH	D/MH	FH	D/MH	FH	D/MH
Carbohydrates									
Arroz	Rice	15 (100)	32 (97)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)
Empanadas	Empanada	0 (0)	0 (0)	6 (40)	7 (21)	5 (33)	19 (58)	4 (27)	7 (21)
Fideos	Noodles	9 (60)	15 (45)	6 (40)	17 (52)	0 (0)	0 (0)	0 (0)	1 (3)
Mote	Hominy	0 (0)	2 (6)	1 (6)	3 (9)	11 (73)	25 (66)	3 (20)	3 (9)
Pan	Bread	15 (100)	27 (82)	0 (0)	0 (0)	0 (0)	2 (6)	0 (0)	4 (12)
Papas	Potatoes	10 (67)	26 (79)	4 (27)	4 (12)	1 (6)	2 (6)	0 (0)	1 (3)
Pastel/galleta	Cake/cookie	0 (0)	2 (6)	5 (33)	9 (27)	8 (53)	14 (42)	2 (13)	8 (24)
Plátano maduro	Ripe banana	6 (40)	12 (36)	5 (33)	7 (21)	3 (20)	12 (36)	1 (3)	2 (6)
Plátano seda	Banana	8 (53)	11 (33)	3 (20)	10 (30)	2 (13)	12 (36)	2 (13)	0 (0)
Plátano verde	Green banana	4 (27)	8 (24)	8 (53)	13 (39)	3 (20)	12 (36)	0 (0)	0 (0)
Tortillas	Tortillas	0 (0)	1 (3)	6 (40)	12 (36)	8 (53)	17 (52)	1 (6)	3 (9)
Tostadas	Toast	1 (6)	2 (6)	0 (0)	3 (9)	8 (53)	17 (52)	6 (40)	11 (33)
Yuca	Yucca	6 (40)	15 (45)	7 (47)	11 (33)	2 (13)	5 (15)	0 (0)	2 (6)
Proteins									
Arvejas	Sweet peas	2 (13)	12 (36)	11 (73)	12 (36)	1 (6)	6 (18)	1 (6)	3 (18)
Atún	Tuna	1 (6)	0 (0)	6 (40)	12 (36)	5 (33)	15 (45)	3 (20)	6 (18)
Carne cerdo	Pork	1 (6)	0 (0)	3 (20)	7 (21)	9 (60)	18 (55)	2 (13)	8 (24)
Carne pollo	Chicken	1 (6)	2 (6)	9 (60)	16 (48)	5 (33)	15 (45)	0 (0)	0 (0)
Carne res	Beef	1 (6)	3 (9)	8 (53)	8 (24)	3 (20)	19 (58)	3 (20)	3 (9)
Churos	Snails	0 (0)	1 (3)	0 (0)	2 (6)	7 (47)	12 (36)	8 (53)	18 (55)
Frijol blanco	White beans	0 (0)	4 (12)	3 (20)	6 (18)	8 (53)	14 (42)	4 (27)	9 (27)
Frijol negro	Black beans	2 (20)	10 (30)	8 (53)	12 (36)	5 (33)	10 (30)	0 (0)	1 (3)
Frijol rojo	Red beans	0 (0)	1 (3)	1 (6)	5 (15)	0 (0)	1 (3)	14 (93)	26 (79)
Guandul	Guandul	1 (6)	12 (36)	12 (80)	12 (36)	2 (13)	6 (18)	0 (0)	3 (9)
Huevos	Eggs	5 (33)	17 (21)	6 (40)	11 (33)	2 (13)	4 (12)	2 (13)	1 (3)
Leche	Milk	1 (6)	9 (27)	9 (60)	12 (36)	3 (13)	7 (21)	2 (13)	5 (15)
Lenteja	Lentils	1 (6)	8 (24)	13 (87)	13 (39)	0 (0)	7 (21)	1 (6)	5 (15)
Mariscos	Seafood	0 (0)	0 (0)	2 (13)	1 (3)	4 (27)	13 (39)	9 (60)	19 (58)
Pescado	Fish	0 (0)	1 (3)	5 (33)	10 (30)	8 (53)	15 (45)	2 (13)	7 (21)
Queso	Cheese	7 (47)	19 (58)	5 (33)	8 (24)	2 (13)	5 (15)	1 (6)	1 (3)
Salchichas	Sausage	0 (0)	1 (3)	9 (6)	8 (24)	0 (0)	16 (48)	6 (40)	8 (24)
Vitamins and minerals									
Cebolla	Onion	13 (87)	31 (94)	0 (0)	1 (3)	1 (6)	1 (3)	1 (6)	0 (0)
Col	Cabbage	0 (0)	1 (3)	4 (27)	15 (45)	9 (60)	11 (33)	2 (13)	6 (18)
Lechuga	Lettuce	2 (13)	10 (30)	9 (60)	19 (58)	3 (20)	4 (12)	1 (6)	0 (0)
Pepino	Cucumber	2 (13)	0 (0)	1 (6)	1 (3)	9 (60)	25 (76)	3 (20)	7 (21)
Pimiento	Bell pepper	8 (53)	20 (61)	4 (27)	6 (33)	2 (13)	5 (15)	1 (6)	2 (6)
Tomate	Tomato	11 (73)	24 (73)	3 (20)	6 (33)	1 (6)	3 (9)	0 (0)	0 (0)
Zanahoria	Carrots	10 (67)	27 (82)	5 (33)	5 (15)	0 (0)	1 (3)	0 (0)	0 (0)
Frutillas	Strawberries	0 (0)	0 (0)	2 (13)	2 (6)	8 (53)	13 (39)	5 (33)	18 (55)
Limón	Lemon	8 (53)	16 (48)	5 (33)	8 (24)	1 (6)	4 (12)	1 (6)	5 (15)
Manzana	Apple	1 (6)	0 (0)	4 (27)	8 (24)	8 (53)	14 (24)	2 (13)	11 (33)
Naranja	Orange	4 (27)	5 (15)	6 (40)	12 (36)	3 (20)	9 (27)	2 (13)	7 (21)
Papaya	Papaya	4 (27)	10 (62)	7 (47)	9 (27)	4 (27)	12 (36)	0 (0)	2 (6)
Tomate árbol	Tree tomato	2 (13)	3 (9)	6 (40)	11 (33)	6 (40)	16 (48)	1 (6)	3 (9)
Tuna	Prickly pear	1 (6)	1 (3)	0 (0)	3 (9)	12 (80)	19 (58)	2 (13)	10 (30)

continued

TABLE 3. Number (percent) of households ($n = 48$) consuming various foods *(continued)*

Spanish name	English name	Period of consumption							
		Daily		Weekly		Monthly		Rarely or never	
		FH	D/MH	FH	D/MH	FH	D/MH	FH	D/MH
Fats and oils									
Aceite vegetal	Vegetable oil	9 (60)	20 (61)	1 (6)	3 (9)	3 (20)	5 (15)	2 (13)	5 (15)
Aceite animal	Animal oil	6 (40)	10 (30)	1 (6)	1 (3)	3 (20)	8 (24)	5 (33)	14 (42)
Azúcar	Sugar	15 (100)	33 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Manteca de cerdo	Lard	7 (47)	15 (45)	0 (0)	1 (6)	5 (33)	3 (9)	3 (20)	14 (42)
Manteca/ mantequilla	Butter/ margarine	1 (6)	8 (24)	5 (33)	5 (15)	5 (33)	12 (36)	4 (27)	8 (24)
Other									
Agua aromátìca	Herb tea	8 (53)	24 (73)	4 (27)	2 (6)	3 (20)	5 (15)	0 (0)	2 (6)
Agua Guitig	Mineral water	1 (6)	3 (9)	3 (27)	2 (6)	5 (33)	19 (58)	6 (40)	9 (27)
Café	Coffee	12 (80)	26 (79)	0 (0)	1 (3)	1 (6)	3 (9)	2 (13)	3 (9)
Té	Tea	3 (20)	6 (18)	3 (20)	6 (18)	6 (40)	14 (42)	3 (20)	7 (21)
Cerveza	Beer	1 (6)	1 (3)	1 (6)	6 (18)	6 (40)	18 (55)	7 (47)	8 (24)
Puro	Pure alcohol	1 (6)	1 (3)	1 (6)	7 (21)	6 (40)	17 (52)	7 (47)	8 (53)
Otro licor	Other alcohol	2 (13)	0 (0)	0 (0)	1 (3)	5 (33)	14 (42)	8 (53)	18 (55)
Achiote	Annatto	8 (53)	29 (88)	5 (33)	2 (13)	1 (6)	2 (6)	1 (6)	0 (0)
Pimenta	Pepper	6 (40)	23 (70)	3 (20)	2 (6)	2 (13)	1 (3)	4 (27)	7 (21)
Sal	Salt	15 (100)	33 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sazonador	Sazonador	11 (33)	25 (76)	2 (13)	2 (6)	0 (0)	1 (3)	2 (13)	5 (15)
Caramelos	Candy	1 (03)	6 (18)	7 (47)	4 (12)	3 (20)	14 (42)	4 (27)	9 (27)
Chocolates	Chocolate	0 (0)	2 (6)	3 (9)	1 (3)	3 (20)	18 (55)	9 (60)	12 (36)
Papa frita funda	Potato chips	0 (0)	1 (6)	4 (12)	8 (24)	5 (33)	9 (27)	6 (40)	15 (45)
Otros fritos funda	Other chips	0 (0)	1 (6)	3 (20)	4 (12)	7 (47)	11 (33)	5 (33)	17 (52)
Helados	Ice cream	4 (27)	8 (24)	6 (40)	5 (15)	2 (13)	13 (39)	3 (20)	7 (21)

a. The organization of the table is based on the Ecuadorian food pyramid. Data indicate the number and percentage of households consuming the item per period of consumption. FH, Female-headed household, $n = 15$. D/MH, dual- or male-headed household, $n = 33$.

the range of variability in terms of frequency of food consumption. However, a review of the information shows some interesting trends. For example, daily consumption of protein foods is limited, although dual- or male-headed households reported consuming milk, lentils, and black beans on a daily basis more often than female-headed households. Generally, however, the female-headed households consumed protein foods on a weekly basis more often than did the male-headed households. Similarly, more female-headed households reported consuming bread, noodles, and several different kinds of bananas daily. Daily consumption of snack foods, such as chips and candy, was more common in male-headed households.

The 24-hour recall interviews provided us with information that was used to evaluate the dietary status of the population. The variety of foods consumed is often considered an indicator of dietary adequacy. By increasing the variety of foods, it is possible to reduce the risk of chronic diseases and increase the probability of meeting nutrient requirements [28–30]. The food-group score has recently been used as a measure of dietary diversity [30]. It is determined by assigning one point for each food group consumed, for a maximum score of six.

The food-group scores of the study population ranged from 1 to 6, with a mean of 3.72 (SD, 1.47). The difference between the food-group scores (fig. 1) for female-headed households (mean, 4.38; SD, 1.19) and male-headed households (mean, 3.45; SD, 1.50) tends toward significance (mean rank, 29.38 and 21.18, respectively; $U = 138$; $p = .056$). When the two types of households were compared for the consumption of the different food groups, only the vegetable group was consumed more commonly in female-headed households than in male-headed households ($\chi^2 = 0.03$; df = 1). The number of meals consumed daily (fig. 2) was significantly different, with female-headed households consuming more meals than male-headed households ($p = .01$).

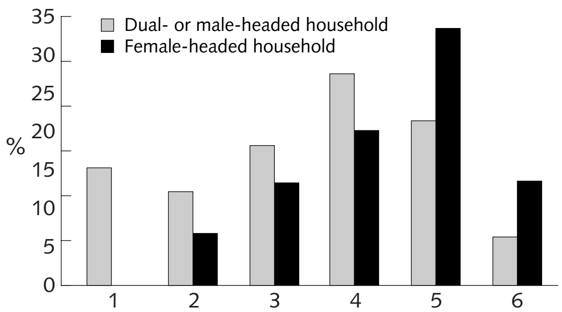

FIG. 1. Distribution of food-group scores of dual- or male-headed households and female-headed households

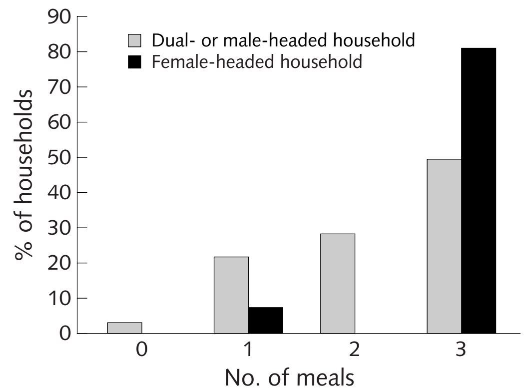

FIG. 2. Distribution of number of meals eaten daily in dual- or male-headed households and female-headed households

Discussion and conclusions

We examined variation in food-acquisition and dietary patterns within the context of differences in household structure in the Afro-Ecuadorian community of San Lucas in the Ecuadorian highlands. Afro-Ecuadorian populations have been neglected by the government and by national and international institutions. Their history of slavery and their status as an ethnic minority have reinforced stereotypes and perceptions, which in turn have led to increasingly limited access to better education, health-care facilities, and employment opportunities. San Luqueños, like the larger Afro-Ecuadorian population, cope with poverty, hunger, and poor standards of living on a daily basis. Under current conditions, female-headed households are increasingly common.

Among the households of San Lucas, we found very few significant differences in the food-acquisition and dietary-intake patterns measured in this study. The question, "Are female-headed households poorer or worse off than male-headed households?" must be answered, "Not always," and "Not when considered in the context of the dietary patterns addressed here." In our analyses, female-headed households do not appear to be very different from male-headed households in terms of their food-acquisition and food-intake patterns. One possible reason for the relative homogeneity of dietary patterns is the fact that the study was conducted from June through August. This period is the harvest season—the most abundant season in the province of Imbabura. Thus, it is likely that resources that were available during the study are not available at other times of the year. It is possible, therefore, that different patterns would emerge in different seasons of the year.

Despite the fact that female-headed households in San Lucas had significantly lower incomes than male-headed households, we did not find differences in the number of foods consumed, the frequency with which items were consumed, or the amount of money spent on food per week. The female-headed households were not necessarily worse off than the male-headed households, although they were poorer in terms of mean monthly income. The fact that there was no significant difference between the two types of household in weekly expenditures for food, despite different income levels, supports the idea that female-headed households focus strongly on the family.

Women in both types of household use strategies for obtaining food from a variety of sources. Food exchange, food gifts, gardening, and procuring wild foods are all ways of ensuring that food is brought to the table or that money is available to purchase food. However, except in the case of hunting, which female-headed households do not seem to use a means of obtaining food, our data do not clearly suggest that there are differences in the frequency or importance of these food-procurement strategies. These are important issues concerning household coping strategies, which will hopefully be elucidated through further research.

Female-headed households had higher food-group scores and a different meal pattern. We found that female-headed households consumed more meals per day than male-headed households. This pattern may be related to a number of factors. Work patterns may influence meal patterns. Also, since they may be coping with scarce resources on a daily basis, the women in charge of providing for their families may be attempting to ensure sufficient food on a daily basis rather than planning resource allocation over longer time periods. Given the clear marginalization of highland Afro-Ecuadorian communities and the growing number of female-headed households within them, it is clear that further research will be important to provide information about the coping strategies used by different households.

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Assessment of bias in national growth-monitoring data: A case study in Zimbabwe

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Abstract

This study assesses the extent to which children under five years of age attending a growth-monitoring program are representative of the population as a whole. Bias in the prevalence of underweight estimated through growth-monitoring is assessed by comparing data from the program with prevalence estimates from the community-based Demographic and Health Surveys of 1988 and 1994. Geographic patterns of attendance at growth-monitoring are also examined through a comparison with census data, and trends in growth-monitoring data are also assessed. Provincial and national estimates of the prevalence of underweight from the two sources were not significantly different in 1988, but significant differences in prevalence estimates were identified in 1994. This suggests that growth-monitoring attendees were less representative of the general population in 1994 than at the start of the study period. The methodology used is transferable elsewhere, since the same data sets exist for many other African countries.

Introduction

Growth-monitoring has been an important component of child health care in many developing countries since the early 1980s. Growth-monitoring makes use of a chart showing the change in a child's weight over time to target supplementary feeding, promote health education, and facilitate epidemiological studies of the prevalence of underweight. Following successful trials in Nigeria [1], UNICEF incorporated growth-monitoring into their strategy to promote child health, and it is now widely used throughout southern Africa.

In Zimbabwe, a growth-monitoring program based on the weight-for-age indicator in children under five years of age has been operating since 1987. The number of children weighed under this scheme is reported monthly for each district through the National Health Information System (NHIS). The number of children falling below the third percentile of the National Center for Health Statistics/World Health Organization (NCHS/WHO) reference population is also reported. This information has several possible uses. National underweight prevalence can be estimated to facilitate international comparisons, and provincial variation in the prevalence of undernutrition can be used to target resources geographically within the country. In addition, trends in prevalence can be examined to assess the impact of policy changes, such as structural adjustment, or environmental changes, such as drought.

Many potential sources of error exist for this system, such as miscalibration of scales, mistakes in plotting weight on the growth chart, and errors in data entry. However, the main difficulty in interpreting the nutritional information gathered through the NHIS is that not all children are weighed. Some children do not visit health centers at all and are therefore not weighed, whereas others are infrequent visitors to health centers. Many of the factors that affect attendance at health centers, such as household income, remoteness of the household from facilities, gender, health status, and religious affiliation, may also affect the nutritional status of the child. For example, children in low-income households may be less likely to attend health centers (because of transportation costs and health fees) and may be more likely to be underweight. It is thus quite possible that the NHIS may underestimate the proportion of underweight children in Zimbabwe. Furthermore, the factors that prevent children from attending health centers may vary geographically,

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seasonally, and over time. In the case of Zimbabwe, for example, real expenditure on health care fell between 1990 and 1994 [2], and cost recovery through user fees became increasingly important [3, 4]. If such changes affect attendance patterns and bias estimates of percentage undernutrition, then comparison between different provinces and different times becomes difficult.

This paper investigates the question of bias in the NHIS growth-monitoring data by two methods. First, patterns of attendance are examined geographically and over time. Second, prevalence patterns in the 1988 and 1994 Demographic and Health Surveys (DHS), which measured children in their home communities rather than at health centers, are compared with prevalence patterns in the NHIS data to see whether the two are different. The implications of this comparison for the use of growth-monitoring data are then discussed.

Methods

Assessment of growth-monitoring attendance

The NHIS collects information on the number of children weighed, as well as the proportion of children suffering from weight-for-age malnutrition. This means that the trends in attendance at the growth-monitoring program can be assessed, which provides one means of assessing the impact of the introduction of health fees discussed earlier.

In order to assess the proportion of children under five years of age being weighed under the growth-monitoring scheme, the size of the total population under five years needs to be estimated from census data. Between the 1982 and the 1992 censuses, administrative boundaries underwent considerable revision as the pre-independence system of government was restructured. Since both the provincial and the sub-provincial boundaries in Zimbabwe changed, it was almost impossible to estimate the rate of population growth at a subnational level. Consequently, trends in growth-monitoring attendance are assessed here at a national rather than a provincial or district level. The Zimbabwean 1992 demographic census and the 1987 intercensal surveys indicate that the average annual percentage increase in children under five years of age over this period was 2.04%, lower than the growth of the population as a whole [5, 6]. This linear percentage increase for the period 1987 to 1992 was applied to the period of the NHIS data (1988 to 1995) to estimate the change in the under-five population from the time of the 1992 census onwards. The total number of children participating in the growth-monitoring program nationally for each month was calculated by aggregating the district totals for the period 1988 to 1995. When a district did not return any statistics for a particular month, total attendance was estimated by averaging the attendance figures from the previous and the following months.

A "snapshot" of attendance at growth-monitoring can also be obtained by comparing the attendance figures from the NHIS with the number of children under five years old recorded in the 1992 census. The census distinguishes between infants less than one year old and children between one and four years old, a distinction that is also used in the NHIS data set. This means that the two data sets are directly comparable for the month of the census, August 1992.

Comparison with the Demographic and Health Surveys

A second method of assessing the impact of variable attendance on the prevalence of undernutrition identified through the growth-monitoring program is to compare this estimate with anthropometric measurements taken in the children's home communities, rather than at health centers. Two such community-based surveys took place in Zimbabwe in 1988 and 1994 under the DHS program funded by the US Agency for International Development. The first survey took place between September 1988 and January 1989 and included child anthropometry, fertility, AIDS awareness, and maternal and child health [7]. The second survey took place between July and November 1994 and covered child and maternal anthropometry, AIDS, maternal mortality, pill compliance, and availability of services [8].

Anthropometric measurements were taken as part of the 1988 DHS for children aged 4 to 59 months, whereas the 1994 DHS covered children under 36 months of age. As anthropometric indicators (weight-for-age, height-for-age, and weight-for-height), the original age, height, and weight data were available for all the children measured, which allowed flexibility in defining age cohorts and applying anthropometric standards. The standard used in the NHIS (the third percentile of the NCHS/WHO population) can therefore be used to define the cutoff point for weight-for-age in the DHS data. The NHIS distinguishes four age categories (under 6 months, 6 to 11 months, 12 to 23 months, and 24 to 59 months), so a comparison with the 1988 DHS data is only possible for the oldest of these cohorts. This can be achieved by including only those children weighed under the 1988 DHS who were six months old or more. Similarly, for the 1994 DHS, a comparison with the NHIS data set is only possible for the age cohorts under 6 months, 6 to 11 months, and 12 to 23 months. In estimating prevalence from the 1994 DHS, observations of underweight were weighted statistically to account for variation in sampling intensity across the country. Children with invalid weight-for-age Z scores (greater or less than 6 standard deviations) were excluded from the analyses.

The mean percentage malnourished nationally was calculated by using NHIS data for the same period as the 1988 and 1994 DHS surveys (September 1988 to January 1989 and July to November 1994). When a district did not return statistics for a given month, the value was replaced with the moving mean of the previous and following months' statistics.

Sampling theory enables DHS estimates of percentage undernutrition to be identified that are significantly different from NHIS estimates. The two DHS surveys used different sampling techniques: the 1988 survey was based on a simple random sample, whereas the 1994 survey was based on a stratified multistage sample. These differences in sampling mean that different significance tests are required for the two samples. For the 1988 survey, the standard error of the estimated proportion underweight in this simple random sample is given by

$$se = \sqrt{\frac{p \cdot q}{n}} \qquad (1)$$

where *se* is the standard error for the sample proportion underweight, p is the proportion undernourished in the sample, $q = 1 - p$, and n is the size of the sample [9]. For the 1994 survey, the procedure for calculating the standard error of the proportion of underweight children was more complex because of the stratified sampling used. The standard error of the proportion of children underweight, as calculated from the total number of children weighed, x, and the total number of children underweight, y, can be estimated by

$$se^2 = \sum_h \left(\frac{a_h}{[a_h - 1]\sum_i z_{hi}^2 - \frac{\sum_i z_h^2}{a_h}} \right) \qquad (2)$$

where a_h is the number of primary selections from stratum h, $z_{hi} = (y_{hi} - r \bullet x_{hi})/x$, and $z_h = \sum z_{hi}$ summing over i. Within the equation for z_{hi}, $y_{hi} = \sum_j w_{hij} \bullet y_{hij}$ and $x_{hi} = \sum_j w_{hij} \bullet x_{hij}$ and are appropriately weighted estimates of the total number of children weighed and the total number underweight within a given stratum h and Primary Sampling Unit i [10].

The results from the two DHS surveys can also be broken down by province and compared with the results from the NHIS. This indicates how far the NHIS can be used for targeting areas with a high prevalence of undernutrition. Following the methodology adopted in a similar study in Malawi [11], this geographic comparison was made in two stages. First, a test was made for significant differences between the NHIS and DHS undernutrition prevalence estimates for each province using equations (1) and (2). Second, the correlation coefficient of the two different sets of estimates of provincial underweight prevalence was calculated. A test was also made for significant differences between prevalences according to age cohort. Descriptive statistics for the DHS surveys were then generated to identify possible changes in the nature of the sample between 1998 and 1994.

Results

Growth-monitoring attendance

Monthly growth-monitoring attendance, expressed as a percentage of the total population under five years of age, is shown in figure 1. Attendance fluctuated from one month to the next, but overall rose quickly during 1988 and early 1989 and then increased slightly until 1992. After 1992, the proportion of children attending the scheme fell slightly. Over the whole period, the proportion of children participating in the scheme every month is estimated to have varied from 17.4% to 27.5%.

Figure 2A shows the percentage of infants under one year of age weighed under the growth-monitoring program in August 1992, and figure 2B shows the percentage of children aged one to four years weighed in the same month. Nationally (excluding Umguza District, for which data are missing) the proportion of infants weighed was 50.4%. This was much higher than the proportion of older children weighed, which stood at only 17.5%. The proportion of infants weighed was highest in the more urbanized parts of Zimbabwe, whereas attendance was lower in the communal lands located in the drier parts of the country. Attendance was higher in central Mashonaland and Manicaland and lower in the provinces of Masvingo and Matabeleland South.

Comparison of the prevalence of underweight according to DHS and NHIS estimates

The provincial and national estimates of the prevalence of underweight from the 1988 DHS survey and the NHIS for this period are shown in table 1, and the same data for the 1994 DHS survey are shown in table 2. Applying equation (1) to these cohort estimates of prevalence suggests that the 1988 DHS provincial estimates of the prevalence of underweight among children 6 to 59 months of age were significantly lower than the NHIS estimates nationally and in five provinces, mostly in western Zimbabwe. The two sets of estimates for 1988 were not significantly correlated ($R = .57$, $N = 10$), although in both the NHIS and the DHS data, Harare and Bulawayo were the provinces with the lowest proportion of underweight. When the provincial prevalence was calculated only for children

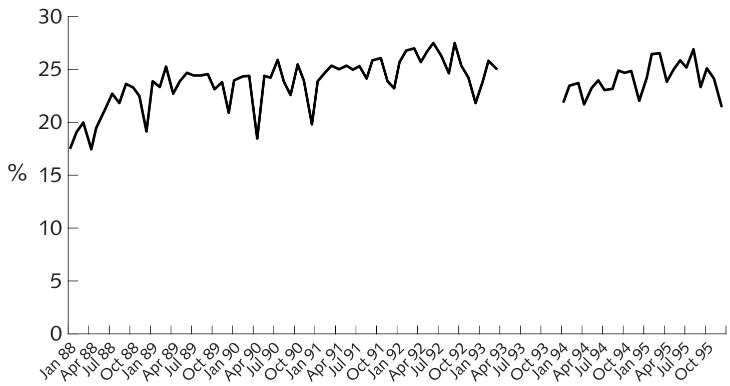

FIG. 1. Percentage of children weighed each month under the growth-monitoring program from January 1988 to December 1995

Source: National Health Information System, Government of Zimbabwe, 1987; Government of Zimbabwe, 1994

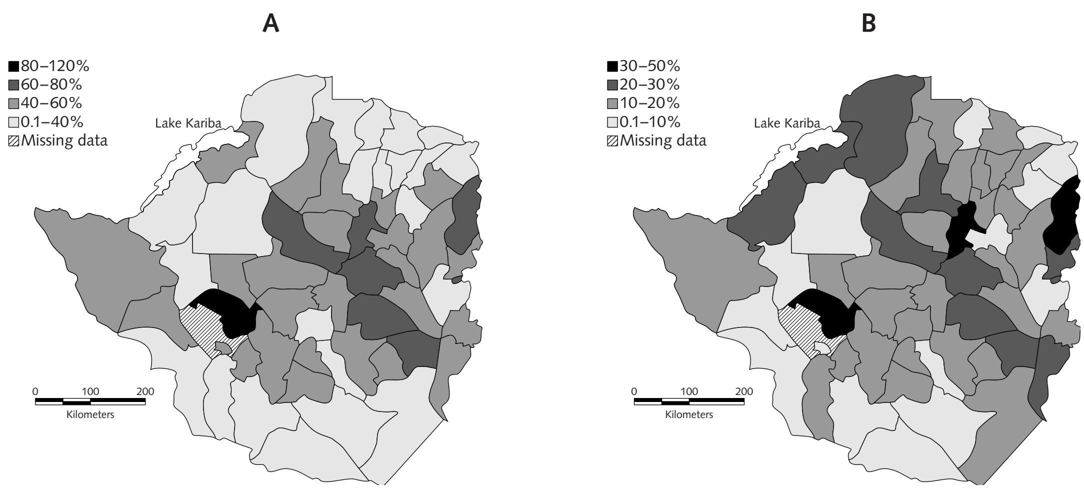

FIG. 2. Percentages of (A) infants under one year of age and (B) children one to four years of age weighed under the growth-monitoring program in August 1992 in different districts of Zimbabwe

Source: Total population from the 1992 census; attendance at growth-monitoring from National Health Information System data; district boundaries from USAID Africa Data Dissemination Service

aged 6 to 23 months, a significant correlation between estimates was identified ($R = .93$, $N = 10$), and only one province, Masvingo, showed significant differences. When equation (2) was applied to the 1994 data, the national estimates of percentage underweight were significantly higher in the DHS survey than in the NHIS. Significant differences were also observed in Mashonaland West Province. In this year, there was a significant correlation between the NHIS and DHS provincial estimates of percentage underweight ($R = .63$, $N = 10$).

The difference between the NHIS and the DHS estimates of the percentage of underweight children was also assessed for the different age cohorts. Table 3 shows the 1988 DHS prevalence estimates compared with those from the NHIS for the same period. The DHS survey covered only children aged 3 to 59 months, and therefore differences in estimated prevalence were calculated only for the cohorts from 6 to 11, 12 to 23, and 24 to 59 months. The NHIS estimate of percentage underweight in the youngest age cohort is not significantly different from the DHS value. The NHIS slightly underestimates the prevalence of underweight in the two older age cohorts. Table 4 compares the 1994 DHS underweight prevalence estimates with those from the NHIS for this period. In this year, the DHS survey covered only children aged 0 to 35 months, and therefore the prevalence of underweight was compared only for the 0- to 5-, 6- to 11- and 12- to 23-month age cohorts. The NHIS

TABLE 1. Prevalence of underweight in children 6 to 59 months of age in different provinces: 1988 Demographic and Health Survey (DHS) versus National Health Information System (NHIS)

	DHS		NHIS	
Province	*n*	Underweight (%)	*n*	Underweight (%)
Bulawayo	151	3.31 ± 2.85**	24,789	7.57
Harare	132	3.03 ± 2.92 NS[a]	300,312	3.37
Manicaland	330	9.00 ± 3.10**	210,092	13.52
Mashonaland Central	170	15.29 ± 5.41 NS	87,182	15.65
Mashonaland East	325	12.00 ± 3.53 NS	182,277	12.11
Mashonaland West	286	10.84 ± 3.60 NS	143,875	12.25
Masvingo	303	6.93 ± 2.86**	122,434	11.93
Matabeleland North	112	9.82 ± 5.51**	60,695	23.52
Matabeleland South	171	8.77 ± 4.24**	51,507	15.34
Midlands	330	14.55 ± 3.80 NS	134,102	13.24
National	2,330	9.96 ± 1.22*	1,317,266	11.26

a. NS indicates that the DHS estimate was not significantly different from the NHIS estimate.
* Estimated prevalence significantly different at the 95% level.
** Estimated prevalence significantly different at the 99% level.

TABLE 2. Prevalence of underweight in children under two years of age in different provinces: 1994 Demographic and Health Survey (DHS) versus National Health Information System (NHIS)

	DHS		NHIS	
Province	*n*	Underweight (%)	*n*	Underweight (%)
Bulawayo	98	5.10 ± 4.09 NS	80,567	2.92
Harare	109	7.34 ± 5.78 NS	283,344	2.88
Manicaland	120	7.39 ± 3.49 NS	181,673	6.10
Mashonaland Central	137	10.79 ± 4.80 NS	99,868	7.06
Mashonaland East	137	4.49 ± 3.45 NS	138,972	6.14
Mashonaland West	137	14.62 ± 5.26**	137,246	5.94
Masvingo	122	7.51 ± 4.92 NS	149,614	4.70
Matabeleland North	212	13.15 ± 3.92 NS	75,724	12.71
Matabeleland South	147	11.86 ± 4.53 NS	66,747	8.72
Midlands	179	9.67 ± 4.41 NS	152,849	6.12
National	1,418	9.22 ± 1.53**	1,366,603	5.64

a. NS indicates that the DHS estimate was not significantly different from the NHIS estimate.
** Estimated prevalence significantly different at the 99% level.

TABLE 3. National prevalence of underweight in children 6 to 59 months of age: 1988 Demographic and Health Survey (DHS) versus National Health Information System (NHIS)

	DHS		NHIS	
Age cohort (mo)	*n*	Underweight (%)	*n*	Underweight (%)
6–11	263	4.56 ± 2.52 NS[a]	378,198	6.58
12–23	537	10.61 ± 2.61*	442,502	13.55
24–59	1,510	10.66 ± 1.56**	496,566	12.78

a. NS indicates that the DHS estimate was not significantly different from the NHIS estimate.
* Estimated prevalence significantly different at the 95% level.
** Estimated prevalence significantly different at the 99% level.

TABLE 4. National prevalence of underweight in children under two years of age: 1994 Demographic and Health Survey (DHS) versus National Health Information System (NHIS)

Age cohort (mo)	DHS		NHIS	
	n	Underweight (%)	*n*	Underweight (%)
0–5	372	1.07 ± 1.12**	325,494	2.53
6–11	394	5.27 ± 2.38 NS	541,044	3.94
12–23	652	16.15 ± 2.97**	500,066	9.52

a. NS indicates that the DHS estimate was not significantly different from the NHIS estimate.
** Estimated prevalence significantly different at the 99% level.

overestimated the prevalence of underweight in the 0- to 5-month age cohort slightly, but it was not significantly different from the DHS value for the 6- to 11-month age cohort. A significant underestimation of percentage underweight by the NHIS was observed in the 12- to 23-month age cohort.

Table 5 shows descriptive statistics for other respondent characteristics in the two DHS surveys. Between 1988 and 1994, there was a slight increase in maternal literacy and a decrease in fertility, as measured by the number of children ever born per respondent. Other characteristics, such as average maternal age, marital status, and mean birthweight, changed little between the two survey rounds.

Discussion

Comparison of the DHS and NHIS data indicates discrepancies between the two sources, with a tendency towards overestimation by the NHIS survey in 1988 and a tendency towards underestimation compared with the DHS in 1994. In 1988 the national estimates of underweight from the DHS and NHIS were different by only 1.3%. This finding is similar to that from earlier work [12], in which the NHIS indicated that 11.4% of children under five years old were below the third percentile for weight-for-age, whereas an estimated 11.5% of under-fives in the 1988 DHS survey were below the 2.3 percentile for weight-for-age. Although the NHIS significantly overestimated the prevalence of underweight in the older age cohorts, such differences were small, and the broad pattern of underweight was very similar. The NHIS overestimated the prevalence of underweight in five provinces, including rural Matabeleland, Bulawayo, Masvingo, and Manicaland. There was no noticeable correspondence between the provinces where prevalence was overestimated and those identified as having low growth-monitoring attendance according to census data. However, the fact that the DHS and NHIS provincial estimates were much better correlated among younger children suggests that problems of bias are greater in the 24- to 59-month cohort.

TABLE 5. Selected descriptive statistics for children aged 6 to 23 months according to the 1988 and 1994 Demographic and Health Surveys[a]

Statistic	1988	1994
Maternal age (yr)	27.8 ± 6.98	27.46 ± 6.77
Married mothers (%)	87.8	87.8
Literate mothers (%)	77.8	82.7
Households owning a radio (%)	42.5	43.1
Children ever born (no.)	3.83 ± 2.65	3.49 ± 2.43
Maternal education (yr)	4.48 ± 1.97	4.34 ± 2.01
Birthweight of child (g)	3,075 ± 492	3,067 ± 646
DPT1 immunization (%)[b]	78.8	78.6
Female children (%)	53.1	50.6
Child deaths (no.)	0.32 ± 0.68	0.24 ± 0.58

a. Plus-minus values are means ± SD.
b. As shown on child's health card.

By 1994 the NHIS was significantly underestimating percentage underweight, both nationally and for the 12- to 23-month age cohort. Province-level estimates of percentage underweight were significantly correlated between the two sources, and there were fewer significant differences between NHIS and DHS provincial estimates for this year. This could be attributed partly to smaller sample sizes and changes in sampling methods, leading to wider confidence limits on provincial DHS estimates. The significant difference in prevalence estimates for Mashonaland West Province did not appear related to overall growth-monitoring attendance, since attendance was higher there than in the other rural provinces.

The assessment of bias in each year has implications for assessing trends in underweight over time. Identification of trends is important in determining the impact of environmental and policy changes on child nutrition. Trend analysis is complicated here by the change in the age of children studied between the 1988 and 1994 DHS surveys. However, the DHS surveys suggest an increase in the prevalence of underweight between 1988 and 1994 in the 6- to 23-month age cohort, the group surveyed in both years. In contrast, the NHIS suggests that the prevalence of underweight declined in this age group over the same period. The trends in underweight identified through the two sources are therefore different.

Increased prevalence of underweight in the DHS has also been identified using a cutoff of –2 SD and has been found to be particularly pronounced in urban areas [13]. Analysis of other DHS indicators suggests increased wasting but decreased stunting during the same period. The increase in percentage underweight in the DHS does not appear to be related to the sample characteristics in table 5. Although there were some changes in sample characteristics, such as a decline in fertility, these are part of a generally recognized trend in Zimbabwe. Rather, the spread of HIV/AIDS, structural adjustment, and drought have been suggested as possible causes of the observed increase [13].

One possible reason for apparent underestimation by the NHIS in 1994 is a change in growth-monitoring attendance patterns. The analysis of attendance trends suggested that during the early years of the program, the government was successful in increasing participation in the scheme, perhaps partly because of the increases in real expenditure on health-care funding that took place at that time. The broadly similar percentages of children attending growth-monitoring from mid-1989 through 1995 suggest that cutbacks in health-care expenditure and the introduction of health fees have not led to drastic reductions in growth-monitoring attendance. The tendency towards underestimation observed in 1994 does not therefore appear to be related to a decline in overall growth-monitoring participation, although bias could still result from changes in the characteristics of those who do participate in the program. Differences could be further exacerbated by transcription errors, scale miscalibration, and problems of age assessment in the NHIS, although it is difficult to quantify these problems using the data sources here.

Apart from changes in the growth-monitoring attendees, discrepancies could also result from problems in the DHS. For example, if the initial sampling frame excludes certain children, the survey might not be representative. Most authors regard DHS data as nationally representative [14], and as a result the surveys have been analyzed nationally for Zimbabwe [15, 16] and used to make international comparisons [17, 18]. The 1994 survey used the Zimbabwe Master Sample (ZMS), which was developed from the 1992 national census [13]. Although it is difficult to conceive of a more comprehensive sampling frame, the sample does therefore exclude those households who have migrated between 1992 and 1994, as well as a small number of women from the ZMS framework (4.4%) who were not interviewed.

Similarly, the DHS surveys may not be representative because of those children within the sample for whom valid weight-for-age data are lacking. Data were missing for 207 children in 1994 (9%), either because they were not measured or because weight-for-age data were invalid. However, a study of the 1994 DHS survey imputed *Z* scores for such children based on age and maternal level of education [13]. When these imputed *Z* scores were included in prevalence estimates, the reported percentage of undernutrition varied by less than one percent. This suggests that the impact of children lacking valid weight-for-age data on prevalence estimates was small in 1994. In the 1988 DHS, a greater proportion of the children selected (613 of 3,098, or 20%) were not weighed, the majority because they were not at home when the survey took place [19]. The greater disparity between national prevalence estimates in 1994 may therefore reflect more comprehensive sampling in the DHS in this year compared with the earlier survey.

Finally, there may be problems with weight measurements and the estimation of children's age. Enumerators for the DHS surveys are generally trained for three weeks at the start of each survey [20] and therefore should be well trained in measuring weight. Of greater concern is the quality of age data, which in some cases is based on recall by the mother and may also reduce the accuracy of DHS estimates. Thus, although the DHS cannot safely be treated as an absolute gold standard (i.e., an error-free representation of true underweight patterns), it is likely to be more accurate than the NHIS estimates.

Conclusions

Considering the financial and other constraints under which the Zimbabwean growth-monitoring data program operates, NHIS and DHS data are remarkably consistent. Although NHIS figures in 1988 overestimated the prevalence of underweight for several provinces, estimates nationally and by age cohort were broadly consistent with those from the DHS. In 1994 there was broad consistency between percentage underweight estimates by province from the two sources, although the NHIS significantly underestimated the proportion of underweight both nationally and for the 12- to 23-month age cohort. Both data sources indicated a lower prevalence in the urban provinces and an increasing prevalence of underweight with age. However, inconsistencies arose when trends were analyzed using the two data sets. The NHIS suggested a decrease in percentage underweight, whereas DHS data indicated an increase during the same period. The discrepancies are most likely to be due to selection bias in the NHIS data, but problems of age assessment in both data sets and incomplete coverage within the DHS could also contribute to these differences.

Comparison with findings concerning other growth-monitoring schemes in different countries suggests that data quality varies according to the details of how the scheme is implemented and the scale of the data used (whether at the national, provincial, district, or clinic level). At the national level, for example, a monitoring system in El Salvador overestimated undernutrition because a large number of sick children were weighed as part of the scheme [21]. In contrast, a Malawian scheme underestimated the prevalence of underweight children because it was based on measurements of healthy children taken at well-child clinics [11]. The Zimbabwean system, based predominantly on children seeking immunization, falls somewhere between these two cases. At the subnational level, the results presented here agree with findings in Botswana and El Salvador [21, 22], where clinic-based data distinguished high prevalence areas. However, these results contrast with findings in Swaziland and Malawi [11, 23], where clinic-based data could not distinguish high-prevalence areas.

Although the conclusions reached are specific to Zimbabwe, the methodology may be applicable in other southern African countries operating growth-monitoring schemes. Because the data sets used (census information, DHS results, and computerized growth-monitoring returns) are available for many other southern African countries, such schemes could be evaluated by using the same methods elsewhere without additional data collection.

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Relationship between health-center performance and the nutritional status of children in Bandung District, West Java Province, Indonesia

Suparman, Siti Muslimatun, and Nugroho Abikusno

Abstract

The objective of this cross-sectional study was to determine whether health-center performance was related to children's nutritional status. Two stages of sampling were used. The first stage used simple random sampling of a finite population, in which 37 out of 100 health centers were selected. The second stage used comparison of two proportions, in which 254 children between 6 and 36 months old were selected from three health centers in the high-performance and three health centers in the low-performance groups. Health-center performance in Bandung District was low (< 61%). Staff capability was the major factor influencing health-center performance and the quality of nutritional service. Performance scores (45.2% for the low-performance group and 60% for the high-performance group) in the two groups of health centers were not positively related to the children's nutritional status ($p > .05$*). The low contribution of health centers to the children's nutritional status was due to a low coverage of health services and similar socioeconomic status of the households.*

Introduction

The standard level of performance of 100 health centers in Bandung District was 92% in 1996, and this decreased to 84% in 1997. The actual coverage of services at the health centers was low, 40% for children's growth-monitoring and 58% for antenatal care [1, 2].

The average prevalence of underweight among children under five years of age in the different health centers was 19% (6%–37%) in 1996 [3]. Presently, Indonesia is suffering the worst economic crisis in its history, and it is predicted that the prevalence of undernutrition among this vulnerable group will increase.

The objective of this study was to determine whether the nutritional status of children was related to health-center performance. The assessment of health-center performance in this study was not intended to evaluate the performance of the health and nutrition programs at the respective health centers.

Subjects and methods

This cross-sectional study was carried out in Bandung District, West Java, Indonesia, in 1998. Bandung District has 100 health centers and 3,456,572 inhabitants, with a population density of 1,118/km^2. The first stage of the study was conducted in 37 health centers that had been functioning for at least three years. The head of the health center and two staff members responsible for nutritional services from each center participated. The number and selection of health centers was determined by using a simple random sampling of a finite population [4]. On the basis of the health-center performance score obtained (described in detail below), 254 children between 6 and 36 months of age were selected randomly from three health centers in the high-performance and three health centers in the low-performance group. The nutritional status of these children was measured during the second stage of the study. The number of children was determined by using a comparison of the prevalence of underweight between low- and high-performance health-center groups [4].

Health-center performance assessment

Health-center performance was assessed on the basis of input, process, output, and staff-capability vari-

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ables, following the Indonesian Ministry of Health guidelines [5] with some modifications [6]. Only variables essential to the delivery of nutrition-related services to children under five were included in the questionnaire. The input variables were geographic location, catchment area, and availability of resources in the respective health center. Process variables referred to the presence of organization and management support (job description, training, and supervision) and availability of nutrition and health service programs. Output variables referred to the coverage of nutrition programs for children under five (growth-monitoring, vitamin A supplementation, immunization, and iron supplementation for pregnant women and neonatal visits). Staff capability was associated with their educational level and basic knowledge of child nutrition and their ability to weigh a child and interpret the growth chart correctly. Also included in staff capability was their perception of the quality of health services. A five-point scale system was used to score each variable related to the health center, with the exception of staff perception of the quality of health services, for which a five-point Likert scale was used [7].

The questionnaire was pretested at 12 health centers in another district near the research area prior to actual data collection. These health centers were randomly selected and had similar characteristics to the actual health centers surveyed.

Health-center categorization

On the basis of percentile categorization of health-center performance, three health centers below the 10th percentile (8%) were considered to have low or substandard performance, three health centers above the 90th percentile (8%) were considered to have high or above-standard performance, and the other health centers were considered to have standard performance.

Nutritional services quality

Nutritional services quality was a variable to express the quality of nutritional services provided by the health staff as an internal factor and users' satisfaction with health services as an external factor [8]. Staff capability was derived from the assessment of health-center performance. The users of health services were the mothers of 6- to 30-month-old children. Their satisfaction was determined by their answers to nine statements on the quality of health services [9]. A five-point Likert scale was used to score users' satisfaction; however, because the mothers had difficulty differentiating between "strongly disagree" and "disagree," and between "strongly agree" and "agree," three scale categories were used instead of five.

Anthropometric measurements of children

Anthropometric measurements were performed on children 6 to 36 months old following standardized anthropometric measurement techniques [10]. Body weight was measured with an SECA 890 electronic weighing scale (Hamburg, Germany) and recorded to the nearest 0.1 kg. The height of children over two years old who could stand was measured by using a microtoise fixed on a wall. For infants and children under two years old who were unable to stand, recumbent length was measured with a measuring board. The reading was taken to the nearest 0.1 cm. A plastic insertion tape was used to measure mid-upper-arm circumference (MUAC) to the nearest 0.1 cm.

Statistical analysis

The health-center performance and nutritional services quality scores were presented as percentages of their potential scores. Data were reported as mean, standard deviation, minimum, and maximum. Percentiles were used to differentiate health-center performance as being low or high, while quartiles were used to categorize household food expenditure. The differences between two groups of normally distributed data were tested by an independent t-test that took into account the homogeneity of variance based on the Lavene test. The Mann-Whitney U test was employed to test the differences between two groups if data were not normally distributed. A p value less than .05 was considered to indicate statistical significance.

Anthropometric data were converted into weight-for-age (WFA), height-for-age (HFA), and weight-for-height (WFH) Z scores by using Epinut of EpiInfo version 6. The cutoff point of -2 Z scores was used to classify children as undernourished by these criteria. A child is defined as undernourished if she or he has one or more of the criteria listed above [11]. All statistical analyses were performed with SPSS software (Windows version 7.5.2., SPSS, Chicago, Ill, USA).

Results and discussion

Health-center performance

Figure 1 shows that health-center performance in Bandung District was low ($52 \pm 5\%$). The input, process, and output variables reached a score of $\leq 50\%$; the lowest was the output variable. The staff capability variable gave the highest contribution to the health-center performance ($70 \pm 8\%$). These profiles were similar to those of the stratification report of the District Health Office of Bandung [2], where 84% of health centers in the district were of standard strata (50–75%). Generally, health-center performance, including its component variables in the Bandung District, was inadequate to support significant quality health services. Similar weaknesses of health centers were identified by the WHO study group, such as poor quality of service, poor teamwork, inadequate financial and material resources, and small staffs [12].

The high-performance group had higher scores on all variables than the low-performance group (table 1). However, the difference in performance between the lowest-performing and the highest-performing health center was only 17%. Comparison of the two different health-center performance variables showed that the input variable had a smaller mean difference than other variables, and the output variable was the most different in the two groups, followed by staff capability. Both groups scored higher in staff capability than in the other variables (60% to 62% and 78% to 82%). Although all of these variables were interrelated in their implementation, low performance in these variables caused these health centers to function suboptimally. There were similar findings in growth-monitoring observations in several pilot projects in different countries, which showed that functioning was one of the essential components causing low growth-monitoring activities [13].

The ratio of health staff to population in the low-performance group was 1:3,644; twice that in the high-performance group (1:1,553) or the standard (1:1,200–1,500)[5]. In particular, higher input variables in the high-performance group were signified by more nutrition equipment, a smaller ratio of staff to population, and more villages (table 2). However, the more villages that had to be supervised, the more resources and services were needed in order to improve the accessibility of health services. Almost all villages

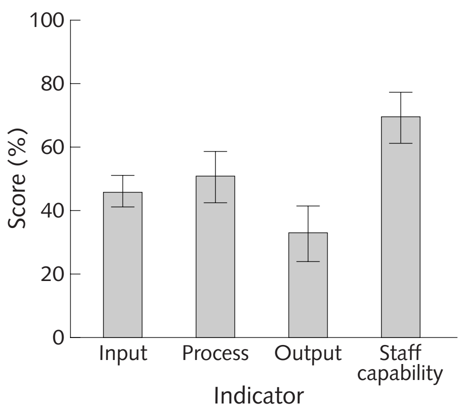

FIG. 1. Scores for health-center performance indicators (mean ± SD; $n = 37$ health centers

TABLE 1. Percentage scores of low- and high-performance health-center groups and their component variables

Variable[a]	Mean ± SD	Minimum	Maximum
Low performance ($n = 3$)			
Input	42 ± 1.9	40	45
Process	45 ± 2.1	43	47
Output	25 ± 6.0	16	31
Staff capability	61 ± 0.8	60	62
Health-center performance score	45 ± 0.5	44	45
High performance ($n = 3$)			
Input	47 ± 3.9	42	50
Process	56 ± 5.2	50	63
Output	47 ± 4.0	41	50
Staff capability	80 ± 1.	78	82
Health-center performance score	60 ± 0.8	59	61

a. The two health-center groups differed significantly in all variables ($p < .05$, Mann-Whitney U test).

TABLE 2. Selected variables in the low- and high-performance health-center groups

Variable	Low-performance ($n = 3$)	High-performance ($n = 3$)
Input		
Equipment[a] (no. of items)	6	7
Staff (no.)	9	18
Staff:population ratio	1:3,644	1:1,553
Villages (no.)	3–4	4–6
Process		
Health-center head received nutrition training (%)	33	67
Staff received nutrition training (%)	33	100
Management support (kinds)	10	13
Integrated program (no.)	2	3
Output		
Growth-monitoring activity		
Accessibility (%)	63	81
Actual coverage (%)	39	60
Effectiveness (%)	25	43
Vitamin A capsule coverage (%)	75	85
Iron supplementation (90 tablets) coverage (%)	54	79
Neonatal visit coverage (%)	32	77
DPT 3 immunization (%)	78	84
Staff knowledge		
Correct child-weighing procedure	2 of 4 steps	3 of 4 steps
Correct identification of factors related to decreasing child status	1 of 4 answers	3 of 4 answers
Correct identification of effects of infectious diseases on child nutritional status	2 of 4 answers	3 of 4 answers

a. Refers only to equipment necessary for the nutrition program, such as weighing scale, growth chart, etc.

had midwives, and therefore it was relatively easy for the community to reach the health services

Process variables in the high-performance group were signified by more trained staff, management support activities, and integrated health services (table 2). These variables were similar to the main predicting factors of health-center performance in another study [14]. Only 17 health centers (46%) were supervised every six months. According to guidelines, supervision should occur at least three times [5]: at the preparation stage, at the beginning of the implementation stage, and during program implementation.

Although several health centers reported an accessibility coverage for growth-monitoring of 80%, the actual coverage was lower than 60%, and the effectiveness was 43% (table 2). Effectiveness and accessibility were significantly correlated with actual coverage ($r = .40$ and $.67$, $p < .001$, Pearson correlation). When these three variables were analyzed by multiple regression, only actual coverage predicted the effectiveness of growth-monitoring ($r^2 = .45$, $p < .001$). This fact was in agreement with the results of another study showing that accessibility guaranteed the quality of service less than actual coverage of service [15]. Therefore, it was difficult for the health center to improve children's nutritional status, since 60% of actual coverage only had an effectiveness of 40%. Thus, health centers still need intensive activity to improve the quality or effectiveness of service.

In Indonesia it is a common practice for the health center, together with health volunteers from the community, to carry out growth-monitoring activities. Therefore, it is also important to ensure that the health volunteers fully understand the significance of growth-monitoring for children's well-being. Parents should also be motivated to understand the health benefits of monitoring their children's growth [16].

The lower staff capability in the low-performance group was related to the small number of staff members and heads of health centers who participated in nutrition training. The heads of health centers have important roles in influencing their staff performance. A study on quality assurance intervention showed that a leader's change in performance score significantly improved other members' performance scores [17]. Understaffing, particularly of paramedical staff, was common in health centers with low performance. It may be related to inadequate allocation of health or paramedical staff in certain health centers. Almost all of the villages had midwives who coordinated health services in their villages; however, transportation for health-service delivery and surveillance was inadequate. At least one functioning motorcycle was available in 29 health centers (78%), whereas four-wheel vehicles were available in only 5 health centers (14%).

There was no association between health-center performance and outcome variables, i.e., children's nutritional status, housing and hygiene conditions, and mothers' nutritional knowledge. Low health-center coverage may be related to similar geographic barriers: for example, 30 health centers (81%) had a combination of flat and mountainous working areas, and 15 health centers (40%) were more than 6 km from their working area community. A distance of more than 5 km between the health center and the community caused a decrease in the use of the health center [14].

The mothers' satisfaction scores (83%) were the same for both health-center performance groups; therefore, staff capability had more influence on the quality of nutritional services. There was a significant association between the quality of nutritional services and health-center performance ($p < .05$). More specifically, there was a significant positive correlation between nutritional services quality and input variable ($r = .53$), process variable ($r = .75$), and output variable ($r = .62$) of health-center performance. However, nutritional services quality had no significant association with outcome variables, such as children's nutritional status and mother's nutritional knowledge. Since nutritional services quality was influenced more by staff capability, adequate training could improve staff capability, not only in the appropriate application of growth-monitoring but also in the provision to clients of essential education on growth-monitoring.

Overall, the main predicting factors of health-center performance were similar to those in an earlier study, i.e., situational factors, population characteristics, health-center characteristics (including size of staff), and management practices [14].

Nutritional status of children and its related factors

The prevalences of stunting, underweight, and wasting in children were 34%, 31%, and 11%, respectively. This showed that children in this area suffered from both acute and chronic undernutrition. Among three indicators of children's nutritional status, stunting tended to decrease only in health centers with the highest performance rating (fig. 2).

Children in the high-performance group were younger than those in the low-performance group (17.0 ± 8.1 vs 19.5 ± 8.0 months, $p < .05$). Nutritional status, i.e., stunting and underweight, was significantly associated with age ($p < .05$). The younger age group had a lower prevalence of undernutrition. For example, stunting increased from 11% for children between 6.0 and 11.9 months to 38% for children between 12.0 and 23.9 months. A similar study in Guatemala showed that the prevalence of stunting, underweight, and wasting was highest in the second year of life [18].

The differences in health-center performance did not influence children's *Z* scores for all indicators and MUAC values. Component variables of differences between the two performance groups in health-

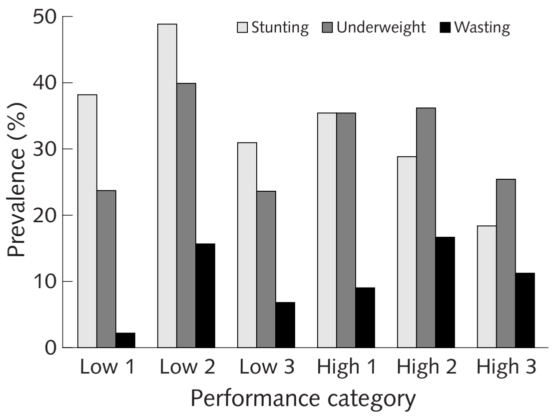

FIG. 2. Prevalence of undernutrition among children 6 to 36 months of age according to health-center performance categories

center performance scores (table 1) and socioeconomic conditions, such as parental educational level and household economic level, were not associated with children's nutritional status.

Children who were weighed more frequently had higher HFA *Z* scores ($p < .05$)(table 3). As shown in table 4, mothers' nutritional knowledge was significantly related to HFA and WFA *Z* scores and MUAC ($p < .05$). Sixty-five percent of the mothers had elementary schooling and 3% had no schooling at all. An evaluation study conducted in three provinces of Indonesia showed that children who were weighed monthly at a weighing post had consistent weight gain [19]. Mothers who frequently attended weighing posts or who contacted health staff had more opportunity to receive health and nutrition information, especially information on child care. These results were similar to those of another study, which showed that the percentage of well-nourished children was correlated with parental education [20].

The socioeconomic status was similar in households in both performance groups. Although total expenditures were similar in both groups, children from the high-total-expenditure tercile (Rp 118,000 [US$14.75] per capita per month) had higher HFA *Z* scores (–1.19 ± 1.48 vs –1.58 ± 1.38, $p < .05$) than children from the lower-total-expenditure tercile (Rp 70,000 [US$8.75] per capita per month). In another study, children from the upper-income tercile tended to have higher *Z* scores than those from the bottom tercile [21].

The differences in health-center performance were not associated with differences in hygiene conditions among households. One reason was related to the low actual coverage of health and nutritional services (< 60%) of the health centers (fig. 1 and table 1). In addition, the parental educational levels and mothers' nutritional knowledge were similar in both groups. In a study in Bangladesh, hygiene and sanitation practices were associated with mothers' knowledge of the causes of disease, parental educational level, and socioeconomic status [22].

Conclusions

The overall performance of health centers in the Bandung District was low, as shown by potential scores of less than 61%. It was difficult for these health centers

TABLE 3. Relationship between number of monthly weighings missed per year and children's nutritional status (mean ± SD)[a]

No. missed	*n*	HAZ[b]	WHZ	WAZ	MUAC[c]
≥ 2	62	–1.92 ± 1.35	–0.82 ± 0.88	–1.78 ± 1.11	14.6 ± 1.7
< 2	190	–1.31 ± 1.39	–0.69 ± 1.15	–1.36 ± 1.14	14.7 ± 1.2

a. HAZ, Height-for-age *Z* score; WHZ, weight-for-height *Z* score; WAZ, weight-for-age *Z* score; MUAC, mid-upper-arm circumference.
b. $p < .05$, corrected by age, *t*-test.
c. Only for children ≥ 1 yr (low $n = 50$; high $n = 127$).

TABLE 4. Relationship between mother's nutritional knowledge as assessed by a questionnaire and children's nutritional status[a]

Mother's score	*n*	HAZ[b]	WHZ	WAZ	MUAC[b,c]
< Mean[d]	111	–1.64 ± 1.24	–0.84 ± 1.05	–1.66 ± 1.01	14.4 ± 1.9
≥ Mean	140	–1.31 ± 1.52	–0.64 ± 1.09	–1.31 ± 1.20	14.9 ± 1.7

a. HAZ, Height-for-age *Z* score; WHZ, weight-for-height *Z* score; WAZ, weight-for-age *Z* score; MUAC, mid-upper-arm circumference.
b. $p < .05$, corrected by age, *t*-test.
c. Only for children ≥ 1 yr (< mean score, $n = 74$; ≥ mean score, $n = 101$).
d. Mean score = 47%.

to contribute to the improvement of their performance outcome.

The small difference in health-center performance scores between the two groups (45.2 ± 0.5% for the low-performance group and 60.0 ± 0.8% for the high-performance group) may be the cause of the similar nutritional status among children in both groups. Inadequate contribution of health-center services to children's nutritional status and their related factors was due to similar socioeconomic conditions among households in both groups, and the low actual health-services coverage of health centers. Low service coverage of health centers was related to a low staff--to-population ratio, poor nutritional training for both health-center heads and staff, and poor management support, including lack of technical supervision. Factors contributing to a better nutritional status of children were younger age, frequent growth-monitoring, mothers' higher nutritional knowledge, and higher socioeconomic status.

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Iron and folate status in urban and rural Costa Rican teenagers

Rafael Monge, Francico Faiges, and Alejandra Rivero

Editorial introduction

Thus far the efforts of the international agencies to prevent anemia in developing countries have focused mainly on iron supplementation in pregnancy, although efforts are increasing to promote iron fortification of cereal flours that can benefit the entire population. It has become increasingly apparent that pregnancy is too late a stage for intervention to prevent iron and folate deficiencies. Women who enter pregnancy with moderate to severe anemia are likely to remain iron deficient during pregnancy, even with iron supplementation. Iron deficiency should be prevented in women of childbearing age, particularly adolescent girls, who are at the highest risk of anemia.

Costa Rica has a much better nutrition and health status than most other developing countries [1]. Its levels of anemia reported in the following paper are remarkably low. Still, more than half of the adolescent girls in this Costa Rican study had anemia and low folate intakes. This is a strong reminder of the importance of preventing these deficiencies in adolescent girls in all countries in order to improve pregnancy outcomes, as recommended by the UNICEF/UNU/MI technical workshop [2]. Folate supplementation in pregnancy is too late to prevent the increase in congenital neural tube defects associated with this deficiency. Hence the recommendation for increased fruits and vegetables in the diet is a sound one. This would provide not only folate, but also ascorbic acid and vitamin A, which improve the absorption of iron. To provide at least a basic level of protection for most of the population, the fortification of wheat flour with iron and folate should be given a high priority, as recommended by the UNICEF/UNU/MI technical workshop [2]. The value of this measure has been most recently demonstrated on a national scale in Venezuela [3].

Editor

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Abstract

This study evaluated the iron and folate status of Costa Rican adolescents and their dietary intake of these micronutrients. Hematological data, serum ferritin, serum folate and iron and folate intakes were evaluated in 307 adolescents aged 13 to 17 years. The prevalence of anemia was 4%. Iron deficiency was found in 3% of adolescents and iron-deficiency anemia in 2% or less. The prevalence of deficient serum folate levels was less than 1%. Over 50% of females and around 20% of males did not consume 66.7% of the recommended daily allowance (RDA) for iron. Iron bioavailability in the diet of urban adolescents was intermediate, whereas it was low in the diet of rural adolescents. Approximately 53% of adolescents did not consume two-thirds of the RDA for

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folate. It is necessary to modify adolescents' food habits in order to ensure an adequate iron and folate intake.

Introduction

Adolescents need more iron and folic acid than children. Boys need more mainly because of an increase in blood volume and erythrocytic mass as a consequence of the growth spurt during puberty, and girls need more because of menstrual losses and in the case of pregnancy [1, 2].

Interest in the iron and folate status of adolescents has been focused on deficiencies of these micronutrients, because of their many negative effects on health. Adolescents with low ferritin levels (< 12 ng/ml) obtain lower scores in tests of academic skills and attention than those whose ferritin levels are within normal limits [3]. Likewise, teenage students with low serum hemoglobin and ferritin levels have lower speed and endurance [4]. In addition, adolescents with anemia are more susceptible to infectious diseases [1], and anemic young girls who become pregnant are at a higher risk of low infant birthweight, preterm birth, and perinatal mortality [5, 6]. Furthermore, a deficient folate status during pregnancy is associated with neural tube defects [7]. Recently, deficient folate status has been associated with homocystinuria [8, 9]. An increased homocysteine concentration in the blood has been identified as an independent risk factor for the development of atherosclerotic lesions [8, 9]. Folic acid can lower homocysteine levels [8].

Individuals develop behaviors in adolescence that are likely to be maintained for life. Therefore, the promotion of appropriate eating habits may prevent the development of several diseases whose processes start at an early age. Awareness of dietary intake patterns for iron and folate status of adolescents and assessment of the association between them provide direction for the design of effective preventive interventions. This is of crucial importance for developing countries, such as Costa Rica, since the demographic and economic transitions are generating changes in teenage diet and lifestyle that greatly impact nutritional status.

This study was conducted to evaluate the iron and folate biochemical status of Costa Rican adolescents and the dietary intake of these micronutrients.

Methods

Sample

Adolescents aged 13 to 17 years were recruited from five urban and five rural public high schools in San José, Costa Rica. In each school, 35 adolescents (7 students per level) were randomly selected for participation. Of the 320 eligible adolescents, 96% consented to participate in the dietary survey. The sample of 307 consisted of 51% males and 49% females. Written consent of the subjects and their parents was required for participation in the study.

Biochemical measurements

After a 12-hour fast, a blood sample was taken from an antecubital vein using vacutainer tubes containing a clot activator (Becton, Dickinson & Co, Rutherford, NJ, USA). Hemoglobin, hematocrit, mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were measured using a Coulter Counter (Coulter S Plus IV, Hialeah, Fla, USA). Serum iron (SI) and total iron-binding capacity (TIBC) were measured colorimetrically (Alpken RFA analyzer, Clackamas, Oreg, USA), and 1% thiourea was added to complex copper to prevent copper interference, as suggested by Gunter et al. [10]. Transferrin saturation (TS) was calculated by dividing serum iron by total iron-binding capacity. Serum ferritin was measured with the Coat-A-Count Ferritin IRMA kit (DPC, Los Angeles, Calif, USA), and serum folate was determined with the Solid Phase No Boil Dualcount kit (DPC). For these analyses, samples were processed in duplicate. The coefficients of variation for the serum ferritin and serum folate assays were 5.3% and 4.6%, respectively.

The diagnosis of anemia was based on hemoglobin value criteria: < 13 g/dl for boys and < 12 g/dl for girls. Iron deficiency was defined as ferritin levels < 12 ng/dl and TS < 16%, and iron-deficiency anemia was defined as iron deficiency and low hemoglobin levels. Deficient and marginal ferritin status were based on cutoff values of < 12 ng/dl and between 12 and 23 ng/dl, respectively. Deficient folate status was defined as levels < 3.0 ng/dl and marginal folate status as levels between 3 and 6 ng/dl.

Dietary intake

Dietary intake was determined by using three-day food records [11], including one weekend day and the previous or next two days (Sunday, Monday, and Tuesday or Thursday, Friday, and Saturday). Each subject recorded the food eaten at home, school, or any other site, including the kind of food eaten, the ingredients of each preparation, cooking technique, brand names, and any other necessary specifications, as explained during the training session. Three to six photographs of each food usually eaten in Costa Rica were used to estimate portion size.

To define the times of food intake or meals, a form was used that was divided into the following sections: breakfast, morning snack (including all food eaten between breakfast and lunch), lunch, afternoon snack (including all food eaten between lunch and dinner), dinner, and evening snack (including all food eaten after dinner).

In order to verify the information registered by subjects, trained nutritionists checked the food record in detail with each adolescent. Foods and three-dimensional food models were used to verify the size of some portions reported by the subjects.

The Monsen method was used to determine dietary iron bioavailability [12]. To evaluate iron intake, a comparison was made with the US recommended dietary allowances (RDAs) [2]. In addition, to evaluate folate intake, a comparison was made with the recent dietary reference intake [13]. Two-thirds (67%) or less of the RDA was used as the criterion for inadequate micronutrient intake.

To determine food sources, a total of 10 major food groups were established, based, when feasible, on similar source characteristics. For example, "tortilla (corn pancake), rice, biscuits, and cereals" were included in the bread and grain group.

Dietary assessments were conducted by six trained nutritionists. Quality-control measures suggested by the NHLBI (National Heart, Lung, and Blood Institute) Clinical Trials Joint Executive Board [14] were used to standardize the training of the nutritionists. The Food Processor (for Windows version 6.0; Esha Research, Salem, Oreg, USA) was used to perform nutrient calculations from dietary data. The amount of iron in rice recorded in the Food Processor database was substituted with the value reported for the product consumed in Costa Rica. There were no other differences in the food supply.

Statistical analysis

Data were examined with SPSS for Windows, using analysis of variance as appropriate for continuous variables and the chi-square test for categorical data. Multiple regression analysis was used to develop models with the different lipids as dependent variables. After examination of univariate relationships between variables, multivariate stepwise models were initially used to identify which of the correlated variables provided the best model with a particular dependent variable. Collinearity was minimized by this approach, and correlation coefficients between independent variables included in the regression models did not exceed 0.3. A p value less than .05 was considered to indicate statistical significance.

Results

The sample consisted of 157 males and 150 females; 50.2% lived in urban areas and 49.8% in rural areas. All subjects were from the same ethnic background (mestizo). Their mean age was 15 ± 1.3 years. All girls studied were already menstruating.

The mean values for biochemical indicators of iron and folate status are presented in table 1. The mean values of hemoglobin, hematocrit, MCV, MCH, and MCHC were similar between urban and rural subjects. The serum ferritin mean value was 8.9 ng/ml higher in urban subjects than in rural subjects, for whom it was 33.0 ng/dl. The mean value of serum folate was higher in rural than in urban subjects (11.7 vs 9.9 ng/dl).

Iron status

Eleven percent of the subjects had deficient iron stores (serum ferritin < 12 ng/dl), and 22% had marginal levels (serum ferritin between 12 and 23 ng/dl) (table 2). The prevalence of serum ferritin lower than 12 ng/dl was significantly higher (p = .01) in girls than in boys (16% vs 6%). Urban boys had a lower prevalence of deficient serum ferritin levels (2.3%), but the difference was not significant (p = .10).

The prevalence of anemia (hemoglobin < 12 g/dl for girls and 13 g/dl for boys) was 4%. The prevalence of anemia was significantly higher among girls (6.8%) than among boys (1.3%)(p = .03). Rural subjects had a higher prevalence of anemia (5.3%) than urban subjects (2.2%), but the difference was not significant (p = .26).

Iron deficiency (serum ferritin < 12 ng/dl and TS <16%) was found in 3% of subjects, and iron-deficiency anemia (iron deficiency and low hemoglobin) was found in 2% or fewer subjects. The prevalence was higher in females and in rural subjects (table 3). If iron deficiency is defined as serum ferritin < 16 ng/dl, as was recently suggested [15], the prevalence is 20%.

Around 1.5% of subjects had MCV levels < 80 fl and MCHC levels < 31 g/L.

TABLE 1. Biochemical indicators (mean ± SD) of iron and folate status in urban and rural Costa Rican adolescents

Indicator[a]	Urban (n = 154)	Rural (n = 153)
Hemoglobin (g/dl)	14.7 ± 1.3	14.4 ± 1.3
Hematocrit (cc%)	43.6 ± 4.5	42.6 ± 3.5
MCV (fl)	85.0 ± 5.6	86.3 ± 4.7
MCH (pg)	28.5 ± 2.2	29.3 ± 1.9
MCHC (g/L)	33.4 ± 0.7	33.9 ± 1.9
Plasma iron (μg/dl)	114.7 ± 38.0	106.4 ± 40.9
TIBC (μg/dl)	396.1 ± 54.8	386.5 ± 65.7
TS (%)	29.7 ± 10.6	28.2 ± 10.7
Serum ferritin (ng/dl)	41.9 ± 34.3	33.0 ± 23.1
Serum folate (ng/dl)	9.9 ± 5.7	11.7 ± 5.3

a. MCV, Mean cell volume; MCH, mean cell hemoglobin; MCHC, mean cell hemoglobin concentration; TIBC, total iron-binding capacity; TS, transferrin saturation.

TABLE 2. Proportion of adolescents with deficient, marginal, and adequate ferritin and folate status

Measurement	Males			Females			Total		
	Urban ($n = 78$)	Rural ($n = 79$)	p^a	Urban ($n = 76$)	Rural ($n = 74$)	p^a	Urban ($n = 154$)	Rural ($n = 153$)	p^a
Serum ferritin									
Deficient (<12 ng/dl)	2.3	9.9	.10	14.6	18.7	.65	8.6	14.1	.18
Marginal (12–23 ng/dl)	17.0	23.5	.42	20.2	26.7	.46	18.6	25.0	.22
Adequate (>23 ng/dl)	80.6	66.6	.07	65.2	54.7	.25	72.8	60.9	.04
Serum folate									
Deficient (<3 ng/dl)	3.4	0.0	.30	0.0	0.0	.11	1.7	0.0	.32
Marginal (3–6 ng/dl)	15.9	9.9	.38	16.9	9.3	.26	16.4	9.6	.11
Adequate (>6 ng/dl)	80.7	90.1	.15	83.1	90.7	.26	81.9	90.4	.05

a. Calculated by χ^2 test.

TABLE 3. Prevalence (%) of anemia, iron deficiency, and iron-deficiency anemia

Population	Anemia	Iron deficiency	Iron-deficiency anemia
Males ($n = 157$)	1.3	<1	<1
Females ($n = 150$)	6.8	5.4	2.1
Urban ($n = 154$)	2.2	1.8	<1
Rural ($n = 153$)	5.3	4.2	1.6

Folate status

The prevalence of deficient serum folate levels (< 3 ng/dl) was less than 1% (table 2). The prevalence was slightly, but not significantly, higher in urban subjects. Marginal serum folate levels (3–6 ng/dl) were found in 13% of the subjects. Urban subjects had a higher prevalence of marginal serum folate levels (16%), but the difference was not significant ($p = .11$). A higher proportion of rural than urban subjects had adequate serum folate levels (90% vs 82%, $p = .05$).

Iron and folate intake

The mean daily reported iron and folate intakes, adjusted per 1,000 kcal, in urban and rural adolescents are presented in table 4. Iron intake was similar in urban and rural subjects, but folate intake was higher in rural subjects ($p < .01$). No differences were found between the energy-adjusted iron and folate intakes of boys and girls.

Around 4% of total iron in the subjects' diets was in heme iron. The percentage of heme iron intake reported by female and rural subjects was significantly lower ($p < .01$) than that reported by male and urban subjects.

On average, nonheme iron bioavailability in the diet of urban subjects was intermediate (5% absorbable nonheme iron), whereas in the diet of rural subjects it was low (3% absorbable nonheme iron). In both areas, nonheme iron bioavailability was low in breakfast foods and high in lunch foods (8% absorbable nonheme iron). For other meals (morning, afternoon, and evening snacks and dinner), the bioavailability was intermediate in urban areas and low in rural areas. No differences were observed between boys and girls in the bioavailability of dietary iron.

Diet contributes approximately 50% of the absorbable RDA of iron for men (1.82 mg) suggested by the Food and Agriculture Organization [16] and approximately 40% of that for women (2.02 mg) (data not shown).

According to the recent dietary reference intakes [13], about 53% of adolescents did not obtain two-thirds of the RDA for folate (fig. 1). Over 60% of females and around 40% of males did not obtain two-thirds of the RDA for folate. A higher percentage ($p = .01$) of urban subjects had inadequate folate intakes than rural subjects (60% and 47%, respectively). Around 20% of rural subjects exceeded the RDA for folate.

Over 50% of females and around 20% of males failed to consume 67% of the RDA for iron. Over 45% of males exceeded the RDA for iron. No significant differences were observed in the percentages of urban and rural subjects with inadequate iron intake.

The bread and grain group was the primary contributor of iron (47%) and the second highest contributor of folate (19%). Rice contributed about 10% of iron intake. Legumes were the major contributor of folate (46%) and the second highest contributor of iron (16%). They contributed about 15% more to folate and iron intake in the rural areas than in the urban areas. Legumes contributed more to iron intake than beef (6%) and more than all meats together (poultry, seafood, beef, and sausage), which contributed only 13%. Meats contributed less to the iron intake in rural areas than in urban areas. Vegetables and fruits together contributed 15% of the folate intake. Likewise, vegetables contributed around 5% of the iron intake.

The mean intakes of vegetables, meats, eggs, breads

TABLE 4. Mean daily intake of energy, iron, and folate

Measurement	Males (n = 157)	Females (n = 150)	p^a	Urban (n = 154)	Rural (n = 153)	p^a
Energy (kcal)	2,342 ± 754	1,930 ± 605	< .01	2,268 ± 681	2,035 ± 731	< .01
Iron (mg/1000 kcal)	5.7 ± 2.7	5.9 ± 2.5	.26	5.6 ± 2.5	5.9 ± 2.7	.29
Heme iron (%)	4.9 ± 1.5	4.4 ± 1.3	< .01	6.0 ± 1.9	3.5 ± 1.2	< .01
Nonheme iron (%)	94.6 ± 1.3	95.6 ± 1.5	< .01	94.0 ± 2.0	96.5 ± 1.7	< .01
Folate (mg/1000 kcal)	136.7 ± 58	137.9 ± 52.2	.33	119.5 ± 50.3	153.5 ± 54.8	< .01

a. Calculated by analysis of variance.

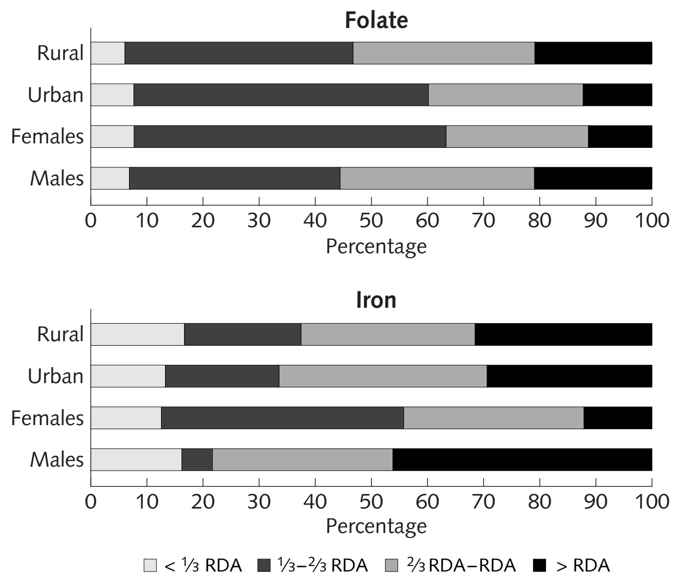

FIG. 1. Percentage of adolescents meeting the recommended dietary allowances (RDAs) for folate and iron

and grains, and milk were higher in urban than in rural areas ($p < .01$). The opposite was true for fruits, roots and tubers, legumes, bananas, and plantains.

Linear regression analysis

By using hemoglobin level as the dependent variable after adjustment for age, a significant independent positive relationship with iron intake (95% confidence interval, 0.003 to 0.058) and folate intake (95% confidence interval, 0.0023 to 0.0321) was found. Likewise, in a similar regression model, a significant independent positive relationship with energy intake (95% confidence interval, 1.787 to 6.557) and hemoglobin level was found.

Discussion

Our results suggest that the prevalence of anemia in Costa Rican adolescents, at least in those who live in the province of San José, is as low as that reported for developed countries, where it ranges between 0.5% and 10% [15, 17–21]. The prevalence of iron deficiency (serum ferritin < 12 ng/dl and TS < 16%) in male adolescents is similar to that reported in the United States (< 1%) [21]. The prevalence of iron deficiency in female adolescents is lower than that reported for the United States (9%) [21]. Furthermore, the prevalence of iron depletion, defined as serum ferritin < 16 ng/dl, is lower than that observed in adolescents in Italy, Sweden, the United States, and Canada [21, 22]. In addition, the prevalence of biochemical folate deficiency is quite low (< 1%), compared with some reports of values ranging from 3% to 48% [23–25].

An explanation for these findings in a developing country may seem difficult, but not for Costa Rica, where the prevalence of infection with parasitic worms and anemia in schoolchildren is much lower than that reported in other Latin American countries [26]. In Costa Rica the prevalence of hookworms is below 0.5% [27]. Likewise, the prevalence of anemia in schoolchildren is below 0.5%, and the prevalence of iron deficiency is no more than 3% in this age group

[28]. Adequate iron status before puberty can meet physiological demands during the growth spurt and menarche, at least temporarily [1].

As has been reported elsewhere [15, 17–21, 29], the prevalence of anemia and iron deficiency was higher in females and in rural areas. Deficient iron status in females could be associated with the onset of menstruation. Kagagimori et al. [30] found that adolescent girls often had low levels of serum ferritin two to three years after menarche. Most of the girls in our study had been menstruating for about two years.

It is important to mention that approximately 20% of male adolescents had marginal serum ferritin levels (12–20 ng/dl), which could be a delayed effect of the somatic growth spurt on iron stores. A similar effect of menarche on serum ferritin levels has been reported by Kagagimori et al. [30].

The low iron status of girls also could be due to their energy intake. Adolescent females may be more vulnerable than males to energy deficiency because of poor dietary habits and self-imposed energy restriction from concerns about weight gain [31, 32]. Nearly 15% of the adolescent girls consumed barely 80% of the RDA for energy. This is very important, because we found a significant independent positive relationship between energy intake and hemoglobin levels (for each kilocalorie increase in the diet, the hemoglobin level increases by 0.21 g/dl).

Pao and Mickle [33] reported that the intake of most nutrients increased proportionally to energy intake. Murphy et al. [34] also noted a strong inverse correlation between energy intake and the number of nutrients for which the intake was less than 67% of the RDA. Likewise, Nicklas et al. [35] reported that children with lower energy intakes were less likely to obtain two-thirds of the RDA for iron than were children with higher energy intakes. We found a strong positive correlation between energy intake and iron and folate intakes ($r = .64$, $p < .01$).

Iron status in adolescents, especially girls, is worse in rural than in urban areas. Rural female adolescents consume nearly 300 kcal/day less than their urban counterparts (1,792 vs 2,084 kcal; $p = .01$). The low bioavailability of dietary iron in rural areas is partly due to a decreased meat intake. Rural adolescents eat approximately 20 g less meat per day than urban adolescents (data not shown). This decreases heme iron intake and limits the increase of bioavailability of nonheme iron. The presence of animal tissue in one of the meals increases nonheme iron absorption two to four times [12].

In rural areas there is low availability of and limited access to meat and vegetables [36]. Therefore, the nutritional ecosystem in rural areas is characterized by a predominance of vegetable protein sources, such as rice and legumes, which have low iron bioavailability (< 5%) and low vitamin C content. However, a higher legume intake by rural adolescents (nearly 45 g more than urban adolescents) can explain the better dietary adequacy of folate as well as the better biochemical folate status observed in these adolescents in comparison to their urban counterparts.

Inadequate biochemical folate status in adolescents may increase their plasma homocysteine levels [8, 9]. Homocystinuria has been identified in adults as an independent risk factor for the development of atherosclerotic lesions [9]. Mean homocysteine levels reached a stable low level only with folate intake of around 400 μg per day [8]. Only 17% of adolescents, mainly rural, reached this intake level. The effect of homocysteine levels on the pathobiology of atherosclerotic lesions has not been studied in young subjects; however, several studies have indicated that correcting the same risk factors identified for older subjects is important for stemming the disease progression in later years [37].

In view of the above and the potential risk of anemia in adolescents with a low iron intake, it would seem appropriate to promote an intake of iron in adolescents that prevents the reduction of transferrin saturation without saturating body stores, in order to prevent the development of anemia and diseases that can become evident in adulthood.

Our results suggest the need for developing primary prevention programs to improve dietary iron intake in rural adolescents, mainly females, as well as to increase the bioavailability of iron in their diets. These interventions may be important strategies to reduce the significant prevalence of anemia observed in Costa Rican adult women, especially in rural areas (approximately 25%) [38]. The promotion of consumption of fruits and vegetables, plus at least 30 g of meat consumed along with other nonheme iron sources, could help achieve this objective. This is very important, because according to our regression model, for each milligram of increase in dietary iron, the level of hemoglobin rises by 0.13 g/dl.

Furthermore, these strategies should encourage the consumption of fresh fruits and green leafy vegetables in order to ensure an adequate folate status and improve iron availability.

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Long-term preventive mass prescription of weekly doses of iron sulfate may be highly effective to reduce endemic child anemia

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Editorial introduction

The authors of the following paper make a significant contribution to establishing the efficacy of weekly iron supplementation to reach an important neglected anemic group, children 6 to 59 months of age. It is disappointing, however, that considerable anemia persists in children 6 to 18 months old. This age group is critical, because iron deficiency at an early age has an adverse effect on cognitive development that is usually persistent and not corrected by iron supplementation at a later age. It must be determined whether the children in this age group simply did not receive enough iron or whether other micronutrients may have been limiting. Both alternatives should be explored.

As the paper points out, the efficacy of weekly iron supplementation has been well established, but there was been skepticism as to whether any supplementation schedule would be effective in ordinary public health programs without special supervision. The fact that providing no more than five minutes of instruction and supplying a bottle of iron sulfate syrup for six months significantly increased hemoglobin levels and decreased anemia prevalence among children in the study is encouraging. However, this study might have benefited from involvement of the parents in the larger survey of which it was a part. It seems too much to expect that one brief instruction will be effective in every population. Nevertheless, similar trials in other populations are certainly indicated.

There is another observation in this paper that is also surprising and encouraging. Among the parents of children originally in the control group who were told that their children had anemia and that they should take them to the health center for treatment, nearly 46% did so, and these children were dropped from the control group. Moreover, for these children, the hemoglobin results are stated to be intermediate between those for the control group children, who did not receive any iron, and those for the children in the iron-intervention group. It is unfortunate that the authors did not supply these data.

To date there have been few efforts to reach the critical 6- to 18-month age group with iron-supplementation programs. It is fortunate that ethical considerations led the investigators to refer children with anemia to the local health center and that the results were encouraging. The possibility of reaching preschool children through referral to the health center has clearly been underestimated. In populations in which there is a high prevalence of iron deficiency and iron-fortified weaning foods are prohibitively expensive, priority should be given to routine preventive weekly iron supplementation of all young children. This paper provides encouragement that, if properly approached, this may be feasible through the health services.

Editor

Abstract

Iron-deficiency anemia in children remains one of the most important nutritional problems faced by developing countries. Well-controlled efficacy studies show that intermittent iron supplementation can improve children's iron status as well as the traditional daily schedule. This gives new impetus to controlling child anemia by weekly preventive iron supplementation. The objective of this study was to evaluate, in a child population in which anemia is highly prevalent, the effectiveness of long-term preventive provision of weekly doses of iron sulfate to all children from 6 to 59 months of age.

Children from both the intervention and the control groups were selected from a random cross-sectional sample of the child population of the city of São Paulo,

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Brazil. Parents in the intervention group were visited in their homes and received nutrition education plus a solution of iron sulfate with the request to give it to their children once a week until a follow-up visit occurred in approximately six months. Parents in the control group received only nutrition education. The effect of the intervention was judged by changes in hemoglobin concentration and the prevalence of anemia. Comparisons between the two groups were made based on an intention-to-treat approach, and all estimates were adjusted for initial hemoglobin concentration, initial age, total duration of follow-up, and family income.

The average hemoglobin gain due to the intervention was 4.0 g/L, with a fall of more than 50% in the prevalence of anemia among the children. The intervention was particularly effective in preventing declines in hemoglobin concentration during the first two years of life. This study demonstrates that long-term preventive weekly iron supplementation of preschool children significantly reduces the risk of anemia under conditions similar to those possible through routine public health programs.

Introduction

Iron-deficiency anemia during infancy and childhood remains one of the most important nutritional problems faced by developing countries. It is estimated that one in two children under five years of age in these countries is anemic (hemoglobin concentration below 110 g/L) [1]. A low dietary intake of available iron and high iron requirements associated with growth, often aggravated by parasitic infestations, are the main causes underlying the high prevalence of child anemia in developing countries [2]. The consequences of iron-deficiency anemia in young children are very serious, including impaired cognitive development and poor educational achievement at later ages [3-5]. Compared with the decreases in deficiencies of vitamin A, iodine, and protein–energy, no significant progress has been made in the control of iron-deficiency anemia among children in developing countries [6].

A population-based household survey in the mid-1990s in São Paulo, Brazil, one of the most economically developed urban centers of Latin America, demonstrated that endemic child anemia was not restricted to poor settings. It found that more than 49% of children aged 6 to 59 months, and nearly 68% of children aged 6 to 23 months, were anemic. Data collected by the same survey suggest that a diet with insufficient available iron (only 23.3% of children received the recommended daily intake of 10 mg of iron) plus a pattern of physical growth (and therefore, normal iron requirements) which resembled the National Center for Health Statistics (NCHS) standards were the main factors contributing to the high risk of child anemia. Fewer than 11% of the children had intestinal parasites, which were mostly *Giardia* and *Ascaris*; no child had hookworms [7].

Fortification of food with iron and the distribution of pharmaceutical iron supplements through the health-care system are the two interventions with greatest potential impact to control iron-deficiency anemia in young children [8]. However, in developing countries, iron-fortified infant foods are usually too expensive to be affordable by the majority of the population, while the distribution of iron supplements in health centers has low coverage and it is usually restricted to pregnant women [8]. Recent well-controlled efficacy studies in iron-depleted Asian preschool children showed that supervised iron supplementation with intermittent dosing schedules (once or twice a week) caused an improvement iron status similar to that caused by daily supplementation [9-11]. This gave a new impetus to the control of child anemia by distribution of an iron supplement. The purpose of the present study was to evaluate whether, in a child population where anemia was highly prevalent and dietary iron was clearly insufficient, an intervention based on the long-term preventive mass prescription of weekly doses of a cheap solution of iron sulfate to children 6 to 59 months of age would be effective in improving hemoglobin concentrations and reducing the prevalence of infant and child anemia, even when the intake was not supervised.

Subjects and methods

Population studied and evaluation design

The study was part of a large, multipurpose, cross-sectional household survey undertaken in the city of São Paulo, Brazil [7]. From September 1995 to September 1996, a random sample of city households (n = 4,560) was visited. Those located in low-, intermediate-, and high-income districts were randomly distributed throughout the survey. Informed consent was obtained from the parents of all participating children, and the study was approved by the Ethics Committee of the School of Public Health of the University of São Paulo.

The hemoglobin concentrations of children from 6 to 59 months of age living in the sampled households (n = 1,158) were measured by a portable photometer. All children examined during household visits between September 1995 and March 1996 (n = 635) were chosen to be control subjects. Parents were told the hemoglobin values of their children, and they were encouraged to increase sources of iron in the children's diet, particularly meat, beans, and dark-green leaves, regardless of the presence or absence of anemia. In the case of anemic control children, the parents were advised to seek treatment for anemia at the nearest public health center. These instructions were limited to three to five minutes.

Children examined from April to September 1996 (*n* = 499) were chosen to receive the iron supplement. Their parents were also informed of their hemoglobin concentrations and received the same feeding advice given to the control group. Additionally, the parents of the children exposed to the intervention received a syrup containing iron sulfate with instructions to give it to their children once a week until a follow-up visit occurred in about six months. The parents of the children in the intervention group also received a calendar to mark the days on which the children were given the syrup. After a period of six to seven months, both the control and the intervention subjects were revisited for a new hemoglobin test. No contact between the families and the research team occurred in the interval between the two visits.

During the second visit to the household, the calendars left with families in the intervention group were taken by the interviewers. In the absence of marked calendars (42.5% of the cases), the interviewers asked the parents about the frequency of administration of the syrup using a structured questionnaire. Parents of the intervention children were also asked about the intake of iron preparations other than the one provided by the study, and parents of the control subjects were asked about the intake of any iron preparation since the initial visit.

Because of address changes, measurement of the hemoglobin concentration during the second visit was not possible in 76 (12.0%) of the 635 control children and 75 (15.0%) of the 499 intervention children. Almost half of the controls (46.7%, or 261 of 559 children) received iron supplements during the follow-up. Most of these children, as anticipated, were anemic children whose parents had followed the research team's advice to take them for medical treatment. Fifty-five of the 424 intervention children (11.0%), equally divided between the anemic and nonanemic groups, received iron supplements other than the one provided by the study. These two groups (261 + 55) were excluded from the impact study. Children whose duration of follow-up was less than 5 months or equal to or greater than 9 months were also excluded (5 control children and 23 intervention children). After these exclusions, the average duration of the follow-up was 6.9 ± 0.7 months for the control group and 7.0 ± 0.8 months for the intervention group. Therefore, the effectiveness of the preventive weekly iron supplementation described in this study was evaluated on the basis of 293 controls and 346 recipients of the intervention.

The dropouts and, particularly, the children excluded from the impact study may have disturbed the expected randomization of the final control and intervention groups for initial hemoglobin concentration and, possibly, for other relevant baseline variables. This possibility is examined and dealt with in the statistical analysis of this study.

Iron preparation

The syrup of iron sulfate provided to children from the intervention group was prepared by the Department of Nutrition at the School of Public Health of the University of São Paulo. It was bottled in brown glass ampoules of 85 ml, which contained 20 mg/ml of elemental iron. The total amount of elemental iron in each bottle was calculated to be much lower than the lethal dose in case a child accidentally swallowed the whole contents [12]. Each bottle was packed with a small, transparent plastic spoon that had marks indicating different volumes of the solution. The recommended weekly intake of the syrup varied according to the child's age at the start of the intervention to provide 30 mg of elemental iron for children 6 to 9 months old, 40 mg for children 10 to 17 months old, 50 mg for children 18 to 29 months old, 60 mg for children 30 to 35 months old, and 80 mg for children 36 to 59 months old. The recommended intake corresponded to approximately 4 mg of elemental iron per kilogram of body weight. Parents of younger children (up to 29 months) received one bottle, and parents of older children received two bottles.

Data collection

The same data collection procedures were used for children in the control and the intervention groups. Before the enrollment of each child in the study, the parents were interviewed to determine the demographic and socioeconomic conditions of the household, including the child's birth date, the total number of residents, and all sources of family income. A capillary blood sample was obtained at the start and at the end of the study by finger skin puncture by health personnel using a manual skin-puncture device (Beckson Dickson, Rutherford, NJ, USA). Hemoglobin concentration was determined at the household, immediately after the puncture, by the cyanomethemoglobin method using a portable photometer (HemoCue, Angelholm, Sweden) [13]. Weight and height measurements were also taken to provide indicators of the general nutritional status of the children. Weight was measured to the nearest 0.1 kg with an electronic scale (Model 7307, Sohenle, Germany) while the child was minimally clothed. Length was recorded to the nearest 0.1 cm using a special length-measuring board for infants (Ahrtag, London), with the child lying down. For children at least two years of age, stature was recorded to the nearest 0.1 cm using a microtoise (SECA bodymeter 208).

Stool samples were collected at the start to be screened for intestinal parasites at the university parasitology laboratory [14]. The parents were told the results of the stool examination during the second visit to the households, and children with positive findings (mostly *Giardia duodenalis* and *Ascaris lumbricoides*; there were no cases of hookworm) received the appropriate drug treatment from the research team. The average daily intakes of energy, protein, vitamin A, and iron were estimated at the start of the follow-up in a systematic subsample of children in both the control and the intervention groups by using 24-hour dietary recalls [15]. Food intake was transformed into nutrients by using the software Virtual Nutri [16], and the percentages of recommended dietary allowances were calculated according to international recommendations [17, 18].

Statistical analysis

Several tests and analyses were employed to assess the impact of the intervention outcomes [19]. The independent *t*-test and the two-sample test for proportions were used to compare the control and intervention groups at the start for the baseline distribution of variables that could influence changes in hemoglobin concentration during the study (initial hemoglobin concentration; age; family income; intestinal parasites; weight-for-age, height-for-age, and weight-for-height indicators; and daily intake and percentage of recommended dietary allowances of energy, protein, vitamin A, and iron). The independent *t*-test was used to compare the two groups for the variation (increment or decrement) in hemoglobin concentration from the beginning to the end of the follow-up. Linear regression analysis was used to model the change in hemoglobin concentration due to the intervention (this is given by the regression coefficient of a dummy variable that indicates the control or intervention status of each child in a linear model, with the hemoglobin variation during follow-up as the dependent variable). Logistic regression analysis was performed to model relative risks (odds ratios) of increasing or decreasing hemoglobin concentrations and the probability of anemia at the end of the follow-up. Linear and logistic analyses provided crude estimates, and the estimates were adjusted according to baseline variables. Confounders considered were baseline variables whose distribution was different among control and intervention children ($p < .20$) and the total duration of the follow-up. The age group at the start of the follow-up (6–17 or 18–59 months) and the attained level of compliance, determined either from marked calendars or from parents' reports (75% or more of the planned doses or lower compliance), were investigated as possible modifiers of the impact of the intervention. All statistical analyses were done using STATA [20]. EpiInfo version 6 [21] was used to enter the data and to generate anthropometric indicators based on the National Center for Health Statistics/World Health Organization (NCHS/WHO) standards [22].

Results

Table 1 presents relevant baseline characteristics of children from the final control and the intervention

TABLE 1. Baseline characteristics of the 6- to 59-month-old children from the control and intervention groups[a]

Characteristic	Control group	Intervention group	*p*
Demography and anthropometry	*n* = 293	*n* = 346	
Age (mo)	36.4 ± 0.9	34.1 ± 0.9	.07
Per capita family income (R$)	298.6 ± 20.5	260.1 ± 19.0	.17
Hemoglobin (g/L)	114.2 ± 0.9	111.4 ± 0.9	.04
Anemia (%)	30.1	41.7	<.01
WAZ	-0.03 ± 0.07	-0.08 ± 0.05	.56
HAZ	0.00 ± 0.06	-0.09 ± 0.05	.28
WHZ	0.08 ± 0.06	0.09 ± 0.05	.91
Intestinal parasites (%)	12.7	11.3	.61
Daily food intake	*n* = 136	*n* = 166	
Energy (kcal/day)	1,405.8 ± 58.9	1,410.3 ± 51.0	.95
Energy (% RDA)	103.9 ± 4.4	109.0 ± 4.2	.39
Protein (g/day)	54.5 ± 2.5	52.6 ± 2.4	.59
Protein (% RDA)	343.9 ± 15.8	346.3 ± 15.4	.91
Vitamin A (μg RE/day)	763.4 ± 128.6	865.8 ± 138.9	.59
Vitamin A (% RDA)	192.8 ± 32.2	219.7 ± 34.8	.57
Iron intake (mg/day)	7.7 ± 0.4	7.6 ± 0.4	.90
Iron intake (% RDA)	77.0 ± 4.0	76.0 ± 4.0	.90

a. Plus-minus values are means ± SE. National Center for Health Statistics *Z* scores: WAZ, weight-for-age; HAZ, height-for-age; WHZ, weight-for-height; RDA, recommended dietary allowance; RE, retinol equivalent.

groups. As expected, due to the higher exclusion of anemic subjects given iron supplements from other sources in the control group, children in this group had higher baseline mean hemoglobin concentrations (114.2 vs 111.4 g/L) and lower baseline anemia prevalence (30.1% vs 41.7%) than children in the intervention group. For the same reason children in the control group had a slightly higher mean age (36.4 vs 34.1 months) and mean family income (R$298.6 [US$291.3] vs R$260.1 [US$253.8]), since anemia prevalence was inversely related to both age and income. Taking into consideration all subjects originally included in the two groups, children in the final control group had a slightly higher prevalence of anemia and lower mean hemoglobin concentration, age, and family income (data not shown).

Other child characteristics that could influence changes in hemoglobin concentration, such as anthropometric indicators, intestinal parasites, and daily intake of energy, protein, iron, and vitamin A, showed a similar baseline distribution in the two groups. It is interesting to note that the means of the anthropometric indicators coincided with the *Z* scores of the NCHS standards in both groups of children, which indicates that the general nutritional status of the studied population was satisfactory. The same impression comes from the subsample data relative to the daily intake of energy, protein, and retinol, but not of iron, a nutrient clearly deficient in the population (table 1). In both groups, few children were breastfed, but nearly all consumed cow's milk (average intake of almost 500 ml/day in the two groups).

Table 2 describes changes in the children's hemoglobin concentration from the beginning to the end of the follow-up period. The increase is twice as high in the intervention group as in the control group (10.0 vs 4.5 g/L); this makes the mean gain in hemoglobin of the intervention group vis-à-vis the control group equal to 5.5 g/L. This gain, or the mean gain due to the intervention, is reduced to 4.0 g/L when it is modeled through a multiple linear regression which controls the comparison between the two groups for initial hemoglobin concentration, initial age (6–11, 12–17, 18–23, 24–35, 36–47, and 48–59 months of age), logarithm of per capita family income (assessed during the first visit to the households), and total duration of follow-up. Both the crude and the adjusted hemoglobin net gain associated with the intervention were statistically highly significant ($p < .01$). All control variables included in the linear model were also highly significant (data not shown).

Table 3 shows the distribution of the study children according to possible modifiers of the impact of the intervention: the child's age at the start of the follow-up and the level of compliance with the intervention. A high level of compliance (evidence of an effective intake of at least three-quarters of the planned doses of the supplement during the follow-up) was found for 62% of all children offered the intervention (54% for 6- to 17-month-old children and 64% for 18- to 59-month-old children).

Table 4 provides estimates of the adjusted mean gain in hemoglobin concentration due to the intervention. These estimates are stratified according to age and level of compliance. As in table 2, they were modeled through a multiple linear regression which takes into account differences between control and intervention children in initial hemoglobin concentration, initial

TABLE 3. Distribution of the studied children according to initial age and treatment group

Initial age (mo)	Control group	Intervention group[a] Low compliance	Intervention group[a] High compliance
6–17	53	33	39
18–59	240	98	176
6–59	293	131	215

a. Children with low compliance received less than 75%, and those with high compliance received at least 75%, of the recommended doses of the supplement.

TABLE 2. Changes in hemoglobin (Hb) concentration (g/L) in 6- to 59-month-old children over 5 to 8 months in control and intervention groups

Group	*n*	Initial Hb	Final Hb	Hb gain	Net Hb gain due to intervention[a] Crude	Net Hb gain due to intervention[a] Adjusted
Control	293	114.2 ± 1.0	118.7 ± 0.8	4.5 ± 1.0	—	—
Intervention	346	111.4 ± 0.9	121.4 ± 0.7	10.0 ± 0.8[b]	5.5 ± 1.3[c]	4.0 ± 0.9[c]

a. Estimates provided by regression coefficients associated with the control or intervention status of each child in linear regression analyses on individual hemoglobin changes. Adjusted estimates take into consideration initial age, initial hemoglobin concentration, log of per capita family income, and duration of follow-up as potential confounders for the association between control or intervention status and hemoglobin change.

b. $p < .000$ compared with the Hb gain in the control group.

c. $p < .000$ for the null hypothesis (no Hb gain).

TABLE 4. Adjusted net gain in hemoglobin concentration (g/L) due to intervention according to child's initial age and level of compliance

Initial age (mo)	All children		Intervention group[a]			
			Low compliance		High compliance	
	Mean ± SE	*p*	Mean ± SE	*p*	Mean ± SE	*p*
6–17	4.1 ± 2.7	.13	1.2 ± 3.1	.69	6.6 ± 3.0	.03
18–59	4.0 ± 0.9	< .01	2.9 ± 1.3	.03	4.7 ± 1.0	< .01
6–59	4.0 ± 0.9	< .01	2.3 ± 1.2	.06	5.0 ± 1.0	< .01

a. Children with low compliance received less than 75%, and those with high compliance received at least 75%, of the recommended doses of the supplement.

age, logarithm of family income, and duration of follow-up. With the control of these variables, the net gain in hemoglobin concentration due to the intervention was much higher for the high-compliance children than for the low-compliance children (5.0 vs 2.3 g/L), particularly for the younger children (6.6 vs 1.2 g/L). But a positive impact of the intervention was seen for all age and compliance strata, and the net gains were statistically significant for all strata except the younger low-compliance children.

Table 5 shows the results of the comparison between control and intervention children for the follow-up incidence of hemoglobin catch-up (defined as changes in hemoglobin concentration greater than +10.0 g/L) and hemoglobin decreases (defined as changes in hemoglobin concentration lower than –10.0 g/L). Adjusted odds ratios provided by logistic regression—which also control for differences between the two groups in initial hemoglobin concentration, initial age, income, and duration of follow-up—indicate that the children who received the intervention tend to be more prone to catch-up concentrations and less prone to decreasing concentrations. Again, the benefits associated with the intervention tend to be directly related to the degree of compliance. In general, the intervention seems to work better in preventing decreases in hemoglobin concentrations (odds ratios for decreases far below 1.0) than in promoting increases in hemoglobin (odds ratios for catch-ups around or not far above 1.0). This preventive effect of the intervention is particularly notable among children from 6 to 17 months old, the age group in which the risk of anemia is higher and the consequences are most serious. Among these children, the intervention reduced by nearly 5 times the chance of a decrease in odds ratios (odds ratio, 0.18; 95% confidence interval, 0.05 to 0.63); the reduction was nearly 15 times when a high compliance was attained (odds ratio, 0.07; 95% confidence interval, 0.01 to 0.63).

Table 6 shows predictions of the prevalence of child anemia at the end of the study in the control and intervention groups. These predictions are obtained by modeling the individual probability of a child's being anemic as a function of his or her intervention status (control or beneficiary), as well as a function of initial hemoglobin concentration, initial age, logarithm of family income, and duration of follow-up. The resulting model was run with the follow-up duration set to seven months and the initial hemoglobin concentration, initial age distribution, and family income all set to the average values observed in the cross-sectional random sample of the total population of children in the city of São

TABLE 5. Adjusted odds ratios (95% confidence intervals in parentheses) for follow-up increasing (> +10.0 g/L) or decreasing (< –10.0 g/L) hemoglobin concentration according to the child's initial age and level of compliance[a]

Age (mo)	Increasing hemoglobin				Decreasing hemoglobin			
		Intervention				Intervention		
	Control	All	Low compliance	High compliance	Control	All	Low compliance	High compliance
6–17	1.0	1.05 (0.42–2.64)	0.39 (0.11–1.39)	2.13 (0.76–5.96)	1.0	0.18 (0.05–0.63)	0.30 (0.08–1.10)	0.07 (0.01–0.63)
18–59	1.0	1.74 (1.10–2.76)	1.14 (0.61–2.14)	2.20 (1.30–3.72)	1.0	0.50 (0.23–1.05)	0.57 (0.21–1.57)	0.44 (0.18–1.06)
6–59	1.0	1.56 (1.04–2.33)	0.86 (0.48–1.54)	2.19 (1.39–3.45)	1.0	0.39 (0.20–0.73)	0.46 (0.20–1.06)	0.33 (0.15–0.70)

a. Odds ratios were adjusted for initial age, initial hemoglobin concentration, log of per capita family income, and duration of follow-up. Children with low compliance received less than 75%, and those with high compliance received at least 75%, of the recommended doses of the supplement.

TABLE 6. Predicted percent prevalence (95% confidence intervals in parentheses) of anemia (hemoglobin < 110 g/L) at the end of follow-up according to the child's initial age and treatment group[a]

Initial age (mo)	Control group	All children	Intervention group[b] Low compliance	High compliance
6–17	58.2 (41.9–72.9)	38.5 (25.8–53.0)	55.8 (33.4–76.1)	24.5 (13.7–40.00)
18–59	13.6 (9.4–19.3)	5.0 (3.1–8.0)	6.7 (3.1–13.8)	4.2 (2.5–7.2)
6–59	21.6 (16.3–27.9)	9.1 (6.3–13.0)	14.1 (8.3–23.0)	6.4 (4.1–9.9)

a. The duration of follow-up was set to 7.0 months, and the initial hemoglobin concentration, initial age, and logarithm of family income in each group were set to the average values found in the random sample of the child population of São Paulo city.

b. Children with low compliance received less than 75%, and those with high compliance received at least 75%, of the recommended doses of the supplement.

Paulo. The prevalences in the table may, therefore, be understood as proxies for the magnitude of child anemia in the city of São Paulo if the iron supplementation had or had not been implemented in the entire city.

A relative reduction in the prevalence of anemia of more than 50% could be predicted for the young child population of the entire city (from 21.6% to 9.1%). A still stronger impact (from 21.6% to 6.4%, or a relative reduction of 70%) would occur if the overall compliance were that of the high-compliance group. The older children seem to respond better to the intervention, probably because more severe anemia (hemoglobin concentration far below 110 g/L) is more frequent at younger ages. The relative reduction in the prevalence of anemia was 60% (from 13.6% to 5.0%) in the older children and 33% (from 58.2% to 38.5%) in the younger children. If maximization of compliance could be achieved, the prevalence of anemia could be reduced to 70% among older children and 24.5% among younger children (a relative reduction of 57%).

Discussion

Because of ethical constraints, the parents of anemic children receiving the intervention were told their children's hemoglobin concentration and were advised to seek medical treatment at the nearest public health center. This ethically mandatory procedure is not always observed in trials with anemic children. Almost half of these children received some iron supplementation during the follow-up and were excluded from the final analysis for this reason. The hemoglobin changes in this group (not shown in this article) were intermediate between those reported in the control and the intervention groups. The relevant differences between the two groups were appropriately dealt with by adjusting all comparisons between intervention and control children for initial hemoglobin concentration, age, and family income.

We also adjusted all comparisons between control and intervention children for duration of observation. The net average improvement in hemoglobin concentration attributed to the intervention was estimated as 4.0 g/L; the intervention was particularly effective in the important first two years of life. It was notable that among children from 6 to 17 months of age, the risk of a decrease in hemoglobin concentration greater than 10 g/L was five times less in the children exposed to the intervention than in control subjects. Extended to the total population of children in the city of São Paulo, the results would predict a reduction in the prevalence of child anemia of more than 50%. In the intervention group, the parents of almost two-thirds of the children gave their children the iron supplement during at least 75% of the weeks during the follow-up period. As would be expected, the impact of the intervention on this group of children was higher, but both the high-compliance and the low-compliance groups benefited significantly from the intervention.

As mentioned in the introduction, three trials undertaken in iron-depleted Asian preschool populations had already demonstrated that supervised intermittent iron supplementation was as efficacious as supervised daily supplementation [9–11]. A meta-analysis of the available evidence for the efficacy of intermittent, as compared with daily, iron supplementation (21 trials) estimated that individuals in different age and physiological groups (children, adolescents, and pregnant women) given weekly iron supplementation had an end prevalence of anemia 1.34 times higher (95% confidence interval, 1.20 to 1.49) than those given supervised daily supplementation [23].

The meta-analysis included four trials with preschool children: two of the three previously cited preschool trials [10, 11] and two still unpublished trials, also undertaken in preschool Asian populations. In these four trials, the end prevalence of anemia was almost the same in the daily and weekly iron-supplementation groups [23]. Only one of the efficacy trials of preschool children reviewed in the meta-analysis had an appropriate control group (children receiving no iron), allowing for the estimation of the absolute efficacy of the weekly iron-supplementation schedule (weekly versus control instead of weekly versus daily). In that trial [11], the prevalence of anemia decreased by 90% in both the daily and the weekly supplemented groups, whereas it increased by one-third in control subjects.

As stated by the authors of the meta-analysis, efficacy (the capacity to produce the desired effects under experimental conditions) is a necessary but insufficient prerequisite to determining the effectiveness of an intervention (the capacity to produce the desired effects under the conditions of expected usage). Since all reviewed preschool trials were undertaken in very controlled settings, the authors of the meta-analysis state that their results do "…not ensure that either method of administration (daily or weekly) will be effective in controlling iron deficiency and anaemia in operational programmes" [23].

The trial undertaken in São Paulo was not designed to address the efficacy of weekly iron supplementation, but rather to explore its effectiveness in reducing child anemia, because of the following features: the intake of the supplement was not supervised but, instead, parents were advised to give the supplement to their children; children whose parents reported poor compliance were not excluded from the impact evaluation; and both the children exposed to the intervention and the control subjects were taken from a random sample representative of the total child population of the city. The fact that the advice to give a weekly dose of the iron supplement was offered in the context of field research, and not by the regular personnel from a service institution, could be considered an argument against generalizing the observed impact. However, it is important to consider that the research team had only a single contact with the families at the start of the study. Moreover, no more than five minutes were spent to explain to the parents the need to protect their children from anemia and the importance of giving them the iron supplement regularly.

The fact that in the São Paulo trial a still relatively high end prevalence of anemia was predicted for children entering the intervention at 6 to 17 months of age (37.6%, compared with a prevalence of only 5.4% for older children) deserves additional comment. We see two likely reasons for this high "residual" prevalence of anemia. The first reason refers to the lower compliance rate achieved by the intervention among younger children: 54% of the younger children received at least three-quarters of the planned doses of the supplement, as compared with 64% of the older children. However, this is surely only a partial explanation, since the end prevalence of anemia was still high (24.5%), even when only younger children with high compliance were considered. The second, and probably most important, reason is that the group of younger children started the intervention not only more affected by anemia (with an initial prevalence of 68.2%, compared with 35.2% in older children) but also with a higher proportion of children with very low hemoglobin levels. One-third of the anemic children 6 to 17 months old had hemoglobin concentrations below 9.0 g/L, as compared with one-sixth of the older children. Therefore, the magnitude of the catch-up needed to "cure" anemia in younger children was obviously much higher than that in older children.

It is also important to observe that in the study population the initial prevalence of more severe anemia (hemoglobin concentrations below 9 g/L) increased very fast up to 18 months of age and then decreased: 6.1% in the first 6 months of life, 19.7% from 6 to 12 months, 23.8% from 12 to 18 months, 17.8% from 18 to 24 months, 10.0% from 24 to 36 months, 3.4% from 36 to 48 months, and 2.7% from 48 to 60 months. This may be an indication that to achieve an "acceptable" end prevalence of anemia at the younger ages it would be essential to initiate the weekly supplementation of iron not at 6 months but even earlier.

It is our conclusion that this trial indicates that long-term preventive weekly iron supplementation of preschool children can significantly reduce the risk of anemia under conditions not far from what would be achieved through routine public health programs. This conclusion is strengthened by a previous nine-week trial undertaken in a West Javanese village, not included in the meta-analysis mentioned above. It demonstrated that iron supplements administered weekly by mothers "under real life community conditions" reduced the prevalence of anemia among two- to five-year-old children by half [24].

The large-scale implementation of a household-level intervention, similar to the one evaluated in São Paulo city but operated by regular health agents and offered to every child when he or she reaches six months of age, has begun in 512 municipalities from the northeast region of Brazil (with an 80% baseline prevalence of anemia around one year of age). It will soon bring new evidence to assess the impact on endemic child anemia that can be expected from programs based on the mass free distribution of iron sulfate weekly [25].

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Decision to fluoridate. 1. Fluoride levels in herbal teas used in Lebanese communities

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Abstract

This study assessed fluoride levels in herbal teas available in the Lebanese market, taking into consideration methods of preparation and time. The fluoride contents of two-minute decoctions prepared from 25 different brands of herbal teas were measured. Only tea and maté were prepared as infusions, and decoctions were prepared from tea, anise, mint, and mixed herbs (0.5, 1, 2, 3, 4, 5, and 10 minutes). For two-minute decoctions, fluoride concentrations ranged from 0.620 to 1.680 mg/L for tea (mean, 0.955 mg/L), 0.056 to 0.060 mg/L for anise (mean, 0.058), 0.030 to 0.037 mg/L for mint (mean, 0.033), 0.010 to 0.068 mg/L for mixed herbs (mean, 0.039), and 0.143 to 0.185 mg/L for maté (mean, 0.160). More fluoride was leached in tea decoctions than in infusions with the same preparation time. Leaching of fluoride reached a maximum after boiling for 10 minutes for tea, mint, and mixed herbs; boiling for 3 minutes for anise; and five runs for maté. Fluoride levels were highest in tea decoctions, followed by mixed herbs, anise, and mint. These findings point to the importance of considering fluoride levels from herbal teas in the overall determination of fluoride intake. In addition, such studies enrich databases required when considering fluoridation as a policy issue.

Introduction

The ingestion of herbal teas is a widespread cultural habit of rural and urban Lebanese communities. Studies have shown that herbal teas could account for a sizeable proportion of total dietary fluoride [1, 2]. The anticariogenic effect of fluoride is well documented in the literature [3], and so are undesirable effects from excessive intake, such as enamel fluorosis [4]. Indeed, health professionals are concerned with the increase of fluoride ingestion from dentifrices, rinses, fluoridated water, and foods and beverages with high fluoride content. This study was set up to determine fluoride levels in herbal teas ingested in urban and rural Lebanese communities, taking into consideration local preparation methods. The findings of this study will constitute a basis for researchers interested in determining the fluoride intake of Lebanese families that consume these herbal teas. In addition, it will enrich the database required for considering policy issues relevant to fluoridation.

Materials and methods

Study population

A random sample of urban and rural families was selected to identify herbal teas used in Lebanese communities and their method of preparation. Urban families (n = 70) in Beirut were selected at random from a list available at the Population Laboratory Project offices [5]. Rural families (n = 90) in three villages of the Shouf area in Mount Lebanon were selected at random from lists obtained from their respective mayors. Data were collected by interview, and all families were responsive because of the nonpersonal nature of the questions.

Herbal teas

The families were surveyed regarding types of herbal teas consumed and their mode of preparation. Based on this survey, the following herbs were identified for inclusion in this study: tea (*Camellia sinensis*, Family Theaceae), anise (*Pimpinella anisum*, Family Umbelliferae), mint (*Mentha pierita*, Family Labiatae), and

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

maté (*Ilex parauariensis*, Family Aquifoliaceae). Mixed herbs were also used. These consisted of a combination of herbs, such as chamomile, cherry stalks, corn silk, hyssop, linden, mallow, rose, St. Joseph wort, senna, etc. None of the families reported drinking decaffeinated teas. A survey was also conducted in the areas of the selected families to identify the brands of herbal teas (packaged and unpackaged) available for their use. Unpackaged herbal tea brands were obtained from specialized shops known as Attars' shops.

Methods of preparation of herbal tea

Maté was prepared as an infusion, tea as an infusion or a decoction, and other herbal teas as decoctions only. An infusion is made by pouring boiling water over the herb and letting it stand until the tea is sufficiently strong. A decoction is made by boiling the herb in water to bring out its fragrant oils [6]. Most of the study families prepared decoctions with an estimated boiling time of two minutes.

Fluoride determination

Twenty-five brands of herbal tea were purchased from local supermarkets and Attars' shops, and the fluoride levels in two-minute decoctions of these brands were calculated. The decoctions were prepared by adding an amount of herbal tea leaves similar to the mean amount reported used by the study families (table 1) to 100 ml of boiling deionized water. Four sets of decoctions were made for every herbal tea brand and the mean values are reported. Assessment was also made of the total fluoride contents of the dry leaves. For the investigation of the effect of infusion and boiling times on herbal teas, the brands most commonly used by the study families were selected. Infusions were prepared by adding the amount of herbal tea used by the study families to 100 ml of deionized water preheated to 85°C. The flasks were placed in a water bath, and samples were taken at intervals of 0.5, 1, 2, 3, 4, 5, and 10 minutes. Four trials were run for tea infusions for each soaking time, and the mean fluoride levels were calculated. Decoctions were prepared as noted above, and samples were taken at intervals of 0.5, 1, 2, 3, 4, 5, and 10 minutes. Four trials were also run for decoctions of herbal teas for each boiling time, and the mean fluoride values were calculated. Maté was prepared as a two-minute infusion and six runs were made for these infusions. A run is defined as pouring boiling water on the maté herbal tea and filtering it out after two minutes, with the initial amount of maté used throughout the six runs. Fluoride levels were calculated for all six runs, in addition to fluoride levels per dry weight of the herbal tea.

Fluoride determinations were assessed after preliminary distillation using an ionic selective meter (Model 407A, Orion Research) with a combination fluoride-selective electrode. Standard fluoride solutions and total ionic strength adjustment buffers (TISAB II) were prepared according to the Standard Methods for the Examination of Water and Waste Water [7].

TABLE 1. Herbs used in the preparation of herbal teas

Herbal tea	Mean ± SD amount used (g/100 ml water)
Tea	1.00 ± 0.05
Anise	2.00 ± 1.30
Mint	0.50 ± 0.00
Mixed herbs	1.00 ± 0.50
Maté	0.69 ± 0.00

Results

Amounts of herbs used

The quantity of herbs used per 100 ml of water varied with the type of herb used. The mean amount was 1.00 ± 0.05 g for tea, 2.00 ± 1.30 g for anise, 0.50 ± 0.00 g for mint, 1.00 ± 0.5 g for mixed herbs, and 0.69 ± 0.00 g for maté (table 1). Similar amounts of maté and mint were used by the study families.

Fluoride levels in different herbal tea brands

For two-minute decoctions, the fluoride concentrations ranged from 0.620 to 1.680 mg/L for tea (mean, 0.955), 0.056 to 0.060 mg/L for anise (mean, 0.058), 0.030 to 0.037 mg/L for mint (mean, 0.033), 0.010 to 0.068 mg/L for mixed herbs (mean, 0.039), and 0.143 to 0.185 mg/L for maté (mean, 0.160) (table 2).

Fluoride levels in tea

Decoctions leached more fluoride from tea than infusions for the same preparation time. Fluoride levels ranged from 0.38 to 0.85 mg/L for soaking times of 0.5 to 10 minutes, and the maximum was reached after soaking for 10 minutes (table 3). Fluoride levels in tea decoctions ranged from 0.460 to 1.050 mg/L for boiling times that ranged from 0.5 to 10 minutes. Leaching of fluoride from tea reached a maximum after boiling for 10 minutes (table 4).

Fluoride levels in other herbal teas

The fluoride levels in other herbal teas are presented in tables 4 and 5. Fluoride levels in anise decoctions ranged from 0.046 to 0.060 mg/L for boiling times that ranged from 0.5 to 10 minutes. Leaching of fluoride started to increase after 2 minutes and reached a maximum after boiling for 3 minutes. Fluoride levels in mint decoctions ranged from 0.030 to 0.083 mg/L

TABLE 2. Fluoride levels in two-minute decoctions prepared from different brands of herbal tea

Brand	Mean ± SD[a] fluoride (mg/L)	Fluoride dry weight (mg/g)
Teas		
Lipton, English Breakfast	1.320 ± 0.050	0.130
Lipton, traditional	0.780 ± 0.050	0.080
Lyons	1.680 ± 0.120	0.170
Twinings, Ceylon Breakfast	0.720 ± 0.050	0.070
Twinings, China Black	0.780 ± 0.050	0.080
Twinings, Earl Grey	0.800 ± 0.080	0.080
Twinings, English Breakfast	1.080 ± 0.050	0.120
Twinings, Lapsang Souchong	0.780 ± 0.100	0.080
Twinings, Orange Pekoe	1.180 ± 0.050	0.120
Unpacked, brand 1	0.680 ± 0.050	0.070
Unpacked, brand 2	1.450 ± 0.060	0.140
Unpacked, brand 3	0.880 ± 0.100	0.090
Unpacked, brand 4	0.620 ± 0.000	0.060
Unpacked, brand 5	0.620 ± 0.050	0.060
Mean ± SEM ($n = 14$)	0.955 ± 0.334	0.096
Anise teas		
Bruggen	0.056 ± 0.005	0.003
London	0.060 ± 0.003	0.003
Mean ± SEM ($n = 2$)	0.058 ± 0.003	0.003
Mint teas		
London	0.030 ± 0.002	0.006
Menthe d'Anjou	0.032 ± 0.002	0.006
Unpacked, brand 1	0.037 ± 0.003	0.007
Unpacked, brand 2	0.031 ± 0.003	0.006
Mean ± SEM ($n = 4$)	0.033 ± 0.003	0.006
Mixed herb teas		
London	0.068 ± 0.000	0.070
Yago	0.010 ± 0.000	0.001
Mean ± SEM (n=2)	0.039 ± 0.041	0.036
Maté teas		
Campeon	0.143 ± 0.005	0.00009
Castiello	0.153 ± 0.021	0.00009
Cruz de Malta	0.185 ± 0.006	0.00001
Mean ± SEM ($n = 3$)	0.160 ± 0.018	0.00006

a. Plus-minus values are means ± SD except where noted as SEM.

TABLE 3. Distribution of fluoride levels in tea infusions according to soaking time

Soaking time (min)	Mean ± SD fluoride (mg/L)	Fluoride dry weight (mg/g)
0.5	0.38 ± 0.04	0.04
1	0.40 ± 0.04	0.04
2	0.53 ± 0.04	0.05
3	0.58 ± 0.05	0.06
4	0.70 ± 0.03	0.07
5	0.72 ± 0.02	0.07
10	0.85 ± 0.01	0.08

for boiling times that ranged from 0.5 to 10 minutes. Leaching of fluoride started to increase after 2 minutes and reached a maximum after boiling for 10 minutes. Fluoride levels in mixed herb decoctions ranged from 0.178 to 0.198 mg/L for boiling times that ranged from 0.5 to 10 minutes. Leaching of fluoride started to increase after 5 minutes and reached a maximum after boiling for 10 minutes. Fluoride levels in maté infusions ranged from 0.001 mg/L in the first run to 0.145 mg/L for the sixth run. Leaching of fluoride from maté reached a maximum after the fifth run. Comparison of fluoride levels in herbal teas and for the same boiling times (0.5–5 minutes) showed that fluoride levels were highest in tea decoctions, followed by mixed herbs, anise, and mint (fig. 1).

Discussion

This study was designed to assess fluoride levels in herbal teas consumed in urban and rural communities in Lebanon, taking into consideration preparation methods and time. The results point to three main findings. First, there is the large variability in two-minute decoctions of available tea brands, a finding that is in agreement with those of other researchers [8–10]. This large variation was expected, because tea is a variable product that can be differentiated on the basis of variety, origin, time of packing, maturity of leaves, and methods of processing and grading

TABLE 4. Distribution of fluoride (F) levels in herbal teas according to boiling time

Boiling time (min)	Tea		Anise		Mint		Mixed herbs	
	Mean ± SD F (mg/L)	Dry wt F (mg/g)	Mean ± SD F (mg/L)	Dry wt F (mg/g)	Mean ± SD F (mg/L)	Dry wt F (mg/g)	Mean ± SD F (mg/L)	Dry wt F (mg/g)
0.5	0.460 ± 0.040	0.046	0.046 ± 0.003	0.094	0.030 ± 0.003	0.002	0.178 ± 0.335	0.018
1	0.540 ± 0.060	0.054	0.046 ± 0.005	0.092	0.030 ± 0.002	0.002	0.178 ± 0.335	0.018
2	0.650 ± 0.030	0.065	0.046 ± 0.005	0.092	0.030 ± 0.002	0.002	0.178 ± 0.335	0.018
3	0.740 ± 0.020	0.074	0.055 ± 0.002	0.010	0.031 ± 0.001	0.002	0.178 ± 0.335	0.018
4	0.740 ± 0.030	0.074	0.058 ± 0.006	0.011	0.048 ± 0.007	0.002	0.178 ± 0.335	0.018
5	0.840 ± 0.030	0.084	0.060 ± 0.010	0.012	0.058 ± 0.005	0.003	0.178 ± 0.335	0.018
10	1.050 ± 0.060	0.100	0.060 ± 0.003	0.012	0.083 ± 0.001	0.004	0.198 ± 0.375	0.019

TABLE 5. Distribution of fluoride levels in maté infusions according to the number of successive runs

Run	Mean ± SD fluoride (mg/L)	Fluoride dry weight (mg/g)
1	0.001 ± 0.005	0.00006
2	0.120 ± 0.008	0.00007
3	0.128 ± 0.010	0.00008
4	0.135 ± 0.013	0.00008
5	0.142 ± 0.005	0.00009
6	0.145 ± 0.006	0.00009

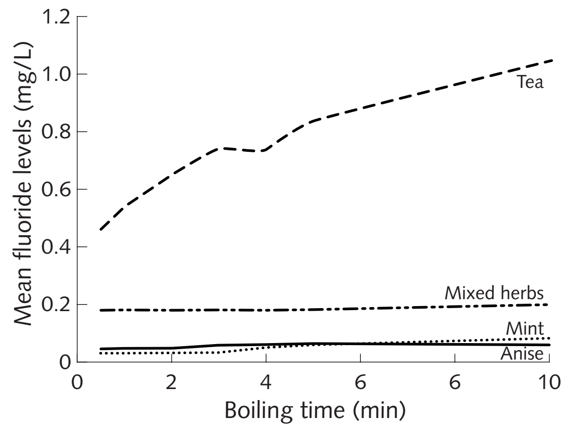

FIG. 1. Distribution of mean fluoride levels according to boiling time

[11]. On the other hand, very low fluoride levels were observed for herbal teas in this study. This finding is similar to those of others who reported negligible fluoride levels in herbal teas, which they attributed to their ingredients [8, 10].

The second main finding was that tea decoctions leached more fluoride than tea infusions for similar preparation times, because maintaining higher temperatures helped leach fluorides in tea. The fluoride levels of tea infusions determined in this study are lower than fluoride levels reported in other studies that also used deionized water and after taking similar infusion times into consideration [1, 8–10]. These differences can be attributed to the brands used in these studies. The third main finding was an increase in fluoride concentration of tea infusions and decoctions with increased brewing and boiling times. This agrees with the findings of others who reported a comparable pattern of increase in fluoride concentrations of tea infusions with time [1, 9, 10]. The maximum fluoride leaching time for tea in this study was approximately 5 minutes.

In conclusion, in this study fluoride levels in herbal teas varied with the type of tea, brand, and method of preparation. The contribution of fluoride in tea to the total fluoride consumed by Lebanese families appears to be substantial, particularly given that the results of this study do not take into consideration fluoride intake from sources such as dentifrices, rinses, foods and beverages in general, nonmilk fluids, and drinking water [12–14]. Information from this study and others should constitute a basis for policy considerations regarding water fluoridation in Lebanon.

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Decision to fluoridate. 2. Intake of fluoride from nonmilk fluids by children under two years of age in Lebanon

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Abstract

This study investigated fluoride intake from fluids consumed by children 0 to 2 years of age residing in urban and rural areas in Lebanon. An area sample of 150 families with children was selected from Beirut and three villages in the Shouf Area in Mount Lebanon (70 and 80 families, respectively). Food diaries for two weekdays and one weekend day were obtained for children aged 0 to 2 years in urban and rural areas (76 and 85 children, respectively), and their fluoride intake from fluids was assessed. Children were given tea, anise, mint, and mixed herbal teas for various reasons, such as their medicinal, warming, and calming effects. They were also given orange flower water, orange juice, and rice water. In urban areas, the fluoride intakes from fluids, expressed as percentages of the estimated safe and adequate (ESA) intake of fluoride, were 48.5% among children 0 to 6 months old, 110.5% among those 7 to 12 months old, 21.9% among those 13 to 18 months old, and 43.5% among those 19 to 24 months old. In rural areas, the ESA fluoride intake from teas was 180.9%, 115.9%, 102.0%, and 71.5% for children aged 0 to 6 months, 7 to 12 months, 13 to 18 months, and 19 to 24 months, respectively. In view of the substantial level of intake of fluoride from nonmilk fluids among children in this study, decisions regarding water fluoridation in Lebanon should consider these results.

Introduction

There is a growing concern regarding the issue of the proposed policy of water fluoridation in Lebanon. Fluoride, an essential nutrient, is effective in maintaining resistant tooth enamel, because the intake of fluoride in infancy overlaps with the period when the enamel of the permanent teeth is mineralized [1]. A dramatic decline in the prevalence of dental caries in children in developed countries was noted with the advent of fluoridation of public water sources [2]. However, a higher prevalence of mild dental fluorosis has been observed in developed countries, because of the widespread ingestion of fluoride from a variety of sources other than water [3, 4]. These sources include fluoride intake from diet, dentifrices, fluoride supplements, fluoride mouth rinses, and gels, as well as from fluoridated water supplies. The fluoride content of drinking water in Lebanon ranges from 0.03 to 1.83 mg/L [5]. These levels constitute the basic consideration in the decision to fluoridate public water supplies, despite the fact that other dietary sources of fluoride exist among Lebanese children and are of the utmost importance. Because nutritional surveys of dietary fluoride intake of children are lacking, this study investigated fluoride intake from fluids consumed by children 0 to 2 years of age and identified the main sources of this mineral. The results of this study may be used by decision makers in Lebanon regarding the issue of fluoridation of the country's public water resources.

Methods

Administrative Beirut was selected as the urban area, and the Shouf region in Mount Lebanon was selected as the rural area. From a list of families available at the offices of the Population Laboratory Survey in Beirut [6], 70 urban families with children under two years of age (76 children) were randomly selected. A list of rural families in three villages in the Shouf area in Mount Lebanon was obtained from their respective mayors, and a random sample of families with children younger than two years was selected for inclusion in the study (80 families and 85 children).

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Demographic data and fluid intakes of children were obtained by interview. Fluid intake included the type and amount of milk given to the children (breastmilk, cows' milk, and milk formula), the type and amount of herbal teas, and water (public water sources or bottled), in addition to other fluids given. Methods of preparation of herbal teas were also obtained. Information was also elicited on vitamin and mineral supplements, fluoride supplements, and mouth rinses given to the children. Questions about oral hygiene practices and types of dentifrice used by the study children were also asked. The type and quantity of infants' fluid intakes were assessed by food-intake diaries, which were designed as part of another research project [7]. Measuring utensils (graduated cups and spoons) were given to the mothers in an effort to standardize intake assessment. Food-intake diaries were completed by the study mothers for two weekdays and one weekend day, and the diaries were collected daily after reviewing their content with the mothers. Fluid-intake diaries were available for 148 infants (for a response rate of 92%).

Samples of potable water from sources used by the communities were collected, and herbal teas and rice water were prepared according to the methods reported by the families. These methods were the basis for the determination of the fluoride content in various types of herbal tea infusions and decoctions, according to soaking and boiling time, as reported elsewhere [8]. Fluoride determinations were assessed after preliminary distillation by using an ion-selective meter electrode (Model 407A, Orion Research) with a combination of selective electrodes. Standard fluoride solutions and total ionic strength adjustment buffers (TISAB II) were prepared according to the Standard Methods for the Examination of Water and Waste Water [9].

Results

The majority of the younger children in this study were breastfed (86.7% in urban areas and 85.9% in rural areas). The mean age at weaning was 7.9 ± 4.7 (SD) months in urban areas and 6.6 ± 5.6 months in rural areas. Milk other than breastmilk was prepared from powdered milk, and none of the powdered milk brands used by the study families was supplemented with fluorine. All of the families used public water sources, except for two families (2.8%) in the rural areas who used bottled water. The fluoride level in the water was 0.09 mg/L in Beirut and ranged from 0.14 to 0.16 mg/L in the three rural villages. None of the vitamin and mineral supplements given to the children contained any fluoride, and no fluoride supplements were given to the children. Furthermore, all the study families reported that they did not brush their children's teeth until after their permanent teeth erupted. Thus, the main dietary fluoride intake of the children was from breastmilk, water used in the preparation of bottled milk, drinking water, herbal teas, and other fluids (orange flower water, rice water, and freshly squeezed orange juice).

Herbal teas were widely used by families in the surveyed areas (100.0% of urban families and 89.4% of rural families), and more rural than urban families gave their children herbal teas (83.1% vs 57.1%) (table 1). Urban families preferred to give tea to their children (60.0%), whereas the majority of rural families gave their children tea, anise, or mixed herbs (47.9%, 43.7%, and 33.8%, respectively) (table 2). The reported reasons for giving herbal teas also varied between rural and urban families. Urban families reported that they gave their children tea out of habit, and that they gave them mixed herbs for colds, anise for stomachaches, and mint for stomachaches and colds. Rural families routinely gave their children tea as a nutritional supplement and for diarrhea. Mixed herbs, anise, and mint were given as remedies for stomachaches, constipation, colds, and, in a few instances, as food supplements and to warm the children (table 3). The study families also reported giving their children rose water for colic and rice water for diarrhea.

The results of the three-day fluid intake diaries showed that urban families gave only water to very young infants (0–6 months), whereas for other age groups, tea was the only fluid given in addition to water. However, in rural households, anise, mixed herbs, tea decoctions, and rice water were given to infants. Rural families gave older children (13–18 months and 19–24 months) orange juice, herbal teas, and rice water (table 4).

TABLE 1. Numbers and percentages of urban and rural families and children using and not using herbal teas

Use of herbal teas	Urban		Rural	
	Families	Children	Families	Children
Yes	80 (100)	49 (57.1)	63 (89.4)	63 (83.1)
No	0 (0.0)	36 (42.9)	7 (10.6)	13 (16.9)

TABLE 2. Percentages of urban and rural families and children using different types of herbal tea

Use of herbal teas	Urban		Rural	
	Families	Children	Families	Children
Tea	100.0	60.0	81.8	47.9
Anise	0	0	59.1	43.7
Mixed herbs	0	10.0	53.0	33.8
Mint	3.8	6.7	25.8	9.8

The daily fluoride intake from fluids, expressed as a percentage of the estimated safe and adequate (ESA) intake [10], is presented in table 5. This fluoride intake was adequate for all the rural children studied and for urban children aged 7 to 12 years. Rural infants aged 0 to 6 months had higher fluoride intakes than urban infants (180.9% vs 48.5% of ESA). Similar fluoride levels were noted in the rural (115.9% of ESA) and urban (110.5% of ESA) children aged 7 to 12 months. This was due mainly to intake of tea and water in urban children and to intake of other fluids in rural children. Higher fluoride intakes were noted in rural than in urban children aged 13 to 18 months (102.0% vs 21.9% of ESA) and 19 to 24 months (71.5% vs 43.5% of ESA).

Discussion

In the wake of concerns regarding fluoridation of water in Lebanon, this study assessed fluoride intake from fluids in children under two years old, the critical period for the calcification of the crowns of the permanent teeth. A random sample of urban and rural children was selected, and their fluid intake was assessed prospectively.

The results of this study pointed to three main findings.

First, the families relied on public water supplies for their drinking water and did not give fluoride supplements or dentifrices to their children. Most of the children were breastfed during the first seven

TABLE 3. Reasons given by urban and rural families for use of different herbal teas (percentage of families)

	Tea		Mixed herbs		Anise		Mint	
Reason	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Stomachache	NA[a]	10.4	NA	15.0	100.0	51.8	50.0	33.3
Diarrhea	NA	31.0	NA	NA	NA	0.0	NA	0.0
Constipation	NA	NA	NA	5.0	NA	17.3	NA	33.3
Cold	NA	NA	75.0	25.0	NA	6.9	50.0	0.0
Calming effect	NA	NA	NA	NA	NA	3.4	NA	0.0
General sickness	NA	NA	20.0	NA	0.0	NA	NA	33.4
Habit	100.0	31.0	NA	20.0	NA	13.8	NA	0.0
Food supplement	NA	27.6	NA	NA	NA	3.4	NA	0.0
Warming effect	NA	NA	25.0	10.0	NA	3.4	NA	0.0

a. NA, Not applicable.

TABLE 4. Percentage of total daily fluid intake supplied by different types of fluids in urban and rural children according to age

	0–6 mo		7–12 mo		13–18 mo		19–24 mo	
Type of fluid[a]	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Herbal teas	—	56.8	53.3	42.3	26.3	31.9	54.5	42.0
Nonherbal fluids	1.1	16.8	—	25.0	—	27.0	—	25.9
Water	98.9	26.4	46.7	31.9	73.7	41.1	45.5	32.1

a. Herbal teas include anise, mint, mixed herbs, and tea. Nonherbal fluids include orange flower water, freshly squeezed orange juice, and rice water.

TABLE 5. Percentage of estimated safe and adequate intake (ESA) of fluoride supplied by different types of fluids in urban and rural children according to age

	0–6 mo		7–12 mo		13–18 mo		19–24 mo	
Type of fluid[a]	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Herbal teas	—	132.0	85.9	78.1	11.5	47.9	34.2	45.4
Nonherbal fluids	1.0	5.4	—	5.2	—	25.9	—	6.5
Water	47.5	43.5	24.6	32.6	10.4	28.2	9.3	19.6
Total	48.5	180.9	110.5	115.9	21.9	102.0	43.5	71.5

a. Herbal teas include anise, mint, mixed herbs, and tea. Nonherbal fluids include orange flower water, freshly squeezed orange juice, and rice water.

months of life. Researchers have noted that the fluoride concentrations in breastmilk remain stable until the fluoride concentration in the water exceeds 1.4 ppm [11]. The fluoride level of the water in Beirut was 0.09 mg/L, and the levels ranged from 0.14 to 0.16 mg/L in the three rural villages. This implies that the amount of fluoride transferred to the younger children from breastmilk was low. These fluoride levels should not dramatically change the mean estimates of dietary intake of fluoride presented in this study. On the other hand, the fluoride content of bottled milk is greatly affected by the brand of powdered milk used and the fluoride content of water used in its preparation. However, no fluoride was found in the milk powder used by the study families. This study also took account of the amount of water used in the preparation of milk formulas for children.

The second main finding was the difference between rural and urban families in the quantity and type of fluids given to their children. Rural families gave more herbal teas, rice water, and orange flower water to their children than urban families, who restricted their children's fluid intake to tea infusions and water. Rural families have more limited resources and hence rely more on home remedies for the alleviation of specific child ailments. They administered herbal teas for their soothing and warming effect, rice water to control diarrhea, orange flower water to control colic, tea infusions to soothe and to supplement food. These findings are similar to those of earlier studies in Lebanon regarding the reliance of poorer rural families on home remedies for the care of children [12].

The third main finding was that adequate levels of fluoride intake were noted, ranging from 71.5% to 180.9% of the ESA for rural children in all age groups and 21.9% to 110.5% of the ESA for urban children in all age groups. This is an expected finding, because rural children are given more herbal teas, which have been found to be a rich source of fluoride [8].

Our findings indicate that dietary fluids provide a substantial proportion of the recommended safe and adequate intake of fluoride for younger children in Lebanon, and that this proportion is significantly higher in rural than urban children. In view of the rising rates of mild fluorosis in countries with fluoridated water supplies, and in the presence of other sources of fluoride exposure available to children, the findings of this study are particularly important with regard to decisions on fluoridation of water sources in Lebanon.

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Use, acceptability, and cost of Incaparina, a commercially processed food in Guatemala

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Abstract

Mass-produced fortified foods are widely used in developing countries to prevent malnutrition. To determine current use of, beliefs about, and acceptance of Incaparina, a mass-produced fortified food that was first introduced in the 1960s, 100 Guatemalan caretakers of children 6 to 23 months old in rural and periurban communities were surveyed and group discussions were conducted. Store owners were interviewed to find out how much Incaparina cost, and health-care personnel were interviewed to find out what recommendations they gave to caretakers about feeding Incaparina to young children. Caretakers served Incaparina 13.7 days a month on average; 82% of the children had consumed Incaparina. The percentage of caretakers who gave Incaparina to children under 5 months of age differed according to the community: 41% in rural and 16% in periurban communities. Caretakers reported positive perceptions about Incaparina's taste (100%), smell (95%), and color (71%). Most caretakers thought Incaparina was inexpensive or moderately priced. Health professionals in both communities recommended Incaparina for children; they differed on recommendations for feeding Incaparina during episodes of diarrhea. Widespread and frequent use of Incaparina over a period of nearly 50 years suggests that mass-produced fortified foods can be important vehicles for improving child nutrition in Guatemala and elsewhere.

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Introduction

Industrially produced low-cost foods are widely consumed throughout the developing world, including Guatemala [1], Peru [2], Algeria, Sri Lanka, Ethiopia [3], and Nigeria [4, 5]. These products aim to improve the food intake and rate of growth of children, as has been demonstrated in controlled efficacy trials [6–13]. Despite the many advantages of industrially processed complementary foods (low cost, minimal preparation time, and high availability), their use and acceptability outside of research settings have been infrequently documented.

In Central America flours cooked with water are called *atoles* [14]. Traditionally prepared atoles contribute to protein malnutrition in children, because the flours commonly used are either corn or rice flour or, very frequently, corn or yucca starch, which do not meet the protein requirements for a growing infant. In 1956 the Institute of Nutrition of Central America and Panama (INCAP) developed a high-quality, vegetable-based flour called Incaparina [15, 16], which was first sold commercially in 1961 [17]. In the 1960s, acceptability trials found that Incaparina reached a significant proportion of the Guatemalan families surveyed [17, 18]. Since then, no consumption studies of Incaparina have been conducted in Guatemala. Up-to-date information on the use of, beliefs about, and acceptability of Incaparina would assist in promoting Incaparina and similar mass-produced products.

The objectives of this study were to determine the current use of, beliefs about, and level of acceptance of Incaparina by caretakers of children aged 6 to 23 months; to document the cost and quantity of Incaparina in local stores; and to learn what feeding recommendations concerning Incaparina health professionals give for young children.

Methods

Study site

This study was conducted in the communities of Santa María de Jesús and Mezquital, Guatemala. Santa María de Jesús is a rural community, predominantly comprised of Cakchiquel-speaking Mayan Indians. Santa María de Jesús is located in the central highlands on the slope of Agua Volcano, 10 km south of Antigua [19, 20]. Mezquital is located in Zone 12 of Guatemala City and is composed of several connected periurban neighborhoods. It is primarily a community of Ladinos (people of both European and Indian descent) whose first language is Spanish.

The socioeconomic, health, sanitary, and nutritional characteristics of Santa María de Jesús have been described previously [21]. Agricultural work is the most common occupation. Most houses have cornstalk walls, tin roofs, and dirt floors and have no piped water [19, 20]. Water must be carried daily from wells located throughout the community.

Most people who live in Mezquital work in the capital. The houses have tin walls and roofs and dirt floors but have piped water. In both communities, unemployment of women is high and the majority of adults, particularly women, have had little or no schooling [19, 20]. The majority of houses in both communities have electricity, and pit latrines are the most common form of human waste disposal.

For both communities, the diet of adults and older children is mainly maize and black beans. Fruits and vegetables are also eaten by the majority of families, although not in amounts sufficient to meet daily nutritional requirements [19, 20]. Mothers typically breastfeed beginning at birth and continue to breastfeed through their child's second year of life. Mothers commonly introduce complementary foods within the first two to three months of life. Common types of complementary foods are atoles, tortillas soaked in coffee, mashed bananas, and rice.

Data gathering

Data were gathered by surveys of caretakers, store owners, and health professionals and group discussions of caretakers living in Santa María de Jesús. All survey instruments were pretested. The main objectives of the caretaker survey were to obtain information and understand the caretakers' use of, beliefs about, and level of acceptance of Incaparina for feeding children. No families without a preschool child were included. Information was gathered about the caretaker, the characteristics of the house where the interview took place, the use and preparation of Incaparina, opinions about the organoleptic qualities of Incaparina, medicinal beliefs, and the use of other atoles available in Guatemala. One hundred caretakers (50 in each community), each of whom cared for a child aged 6 to 23 months, were surveyed. The caretakers were asked to demonstrate the amounts of Incaparina, water, sugar, and milk (if any) they used for preparing Incaparina, and the ingredients were weighed. The surveys were conducted in Cakchiquel in Santa María de Jesús and in Spanish in Mezquital by local fieldworkers. The results might be quite different in other communities, but it was not possible to include more communities in this study.

Santa María de Jesús is divided into four neighborhoods. Within these neighborhoods, 50 households were randomly selected to participate in the survey. Mezquital is composed of over 1,000 households and is divided into approximately 10 neighborhoods. Four neighborhoods in Mezquital were selected for interviews for logistical and safety reasons, each in a different direction (north, south, east, and west) from the main government-funded health center.

The objective of the store-owner survey was to obtain information on the cost and quantity of Incaparina sold. Five owners were surveyed, one owner in each neighborhood plus one store in the market. Stores were chosen because they were frequented by a large number of people in the neighborhood. The inclusion criterion was that Incaparina was available for purchase in the store at the time of the interview.

The objectives of the health professional survey were to obtain information on whether the health-center personnel recommended Incaparina for small children and/or their families and, if so, for what ages and cases it was recommended and what recommendations were given. Health professional surveys were conducted in each community at the main health center. In Santa María de Jesús there was both a government-funded health center and a dispensary funded by the Catholic Church. Doctors who advised and treated women on reproductive and child health issues were interviewed. Mezquital had only one health center; the survey was done by three nurses who had the most frequent contact with caretakers who came to the health center for checkups and treatment.

Upon completion of all 100 caretaker interviews, two caretaker focus-group discussions were conducted in Santa María de Jesús. The objectives of the discussions were to clarify and confirm ideas or concepts that arose during the survey. Practices related to frequency and timing of preparation, preferences in consistency, and opinions about the organoleptic qualities of Incaparina were discussed. The inclusion criteria were that the caretakers had not participated in the caretaker survey and that they were currently caring for a child aged 6 to 23 months. Eight caretakers, two from each neighborhood, were included in each discussion. Snacks and a 75-g bag of Incaparina were provided to each caretaker. Each group discussion lasted approximately

45 minutes and was conducted in Cakchiquel. Both the facilitator and a fieldworker took notes on what was discussed, and afterwards, the principal investigator, facilitator, and fieldworker reviewed the participants' comments.

Data analysis

Coding, computing, and analysis of the quantitative data collected were done using EpiInfo version 6.02 [22]. Univariate and bivariate (chi-square and *t*-test) analyses were carried out on all quantitative data. Values of p less than .05 were considered to indicate statistical significance. The group discussion results were translated, categorized, analyzed by themes, and summarized.

Results

Caretaker demographics

All caretakers surveyed were women except for one man. Their mean age was 29 years; the mean was higher in Santa María de Jesús (table 1). Sixty-eight percent of those interviewed had less than four years of schooling; the level of education was higher in Mezquital. The average number of children born to the women was higher in Santa María de Jesús than in Mezquital (4.6 vs 3.4). Most caretakers were currently breastfeeding (69%). The majority lived in houses with roofs made of metal sheets (93%)(data not shown) and with dirt floors (73%). In Mezquital most caretakers (60%) lived in houses with walls made of metal sheets, whereas in Santa María de Jesús most caretakers (54%) lived in houses with walls of corn stalks (data not shown). In Santa María de Jesús 66% of caretakers used a fire pit for cooking, whereas in Mezquital 90% used a wood-burning stove. There was also a significant difference between the communities in water sources.

TABLE 1. Demographic and socioeconomic characteristics of caretakers in survey

Characteristic	Santa María de Jesús ($n = 50$)	Mezquital ($n = 50$)	p^a
Caretaker's age—yr			
Mean	30.4	27.5	.05[b]
Range	17–55	16–44	
Years of education—no. (%) of caretakers			
0	20 (40)	7 (14)	
1–3	20 (40)	21 (42)	
4–6	8 (16)	17 (34)	
7–12	2 (4)	5 (10)	.001[c]
No. of children			
Mean	4.6	3.4	.02[b]
Range	1–9	1–7	
Currently breastfeeding—no. (%)	35 (70)	34 (68)	NS[c]
Child's age—mo			
Mean	14.0	12.8	NS[b]
Range	6–23	6–22	
Dirt floor—no. (%) of households	34 (68)	39 (78)	NS[c]
No. of rooms—no. (%) of households			
1–2	34 (68)	34 (68)	
3–4	12 (24)	15 (30)	
≥ 5	4 (8)	1 (2)	NS[c]
Water supply—no.(%) of households			
No piped water	44 (88)	4 (8)	
Piped water	6 (12)	46 (92)	.0001[c]
Type of kitchen—no. (%) of households			
Fire pit in ground	33 (66)	1 (1)	
Elevated fire pit	9 (18)	3 (6)	
Wood stove	8 (16)	45 (90)	
Gas stove	0	1 (2)	.0001[c]

a. NS indicates not significant ($p > .05$).
b. *t*-test.
c. Chi-square test.

Use of Incaparina

Table 2 summarizes caretakers' reported use of Incaparina for family members and children aged 6 to 23 months. Ninety-nine percent reported that their family members consumed Incaparina. Most caretakers had prepared Incaparina within the past 30 days, and about one-third said they prepared Incaparina every day. Some caretakers made large amounts of Incaparina at once and used it over several days.

More than 80% of caretakers had given their 6- to 23-month-old children Incaparina at some time in the past. The age of introduction differed significantly between communities. Forty-one percent of caretakers in Santa María de Jesús introduced children to Incaparina before 5 months of age, as compared with only 16% in Mezquital (fig. 1). In group discussions, the reported age of introduction and the rationale for introduction were similar to those in the caretaker survey. Children were introduced to Incaparina at around 6 months of age if their mothers went to work in the fields or 12 months if their mothers stayed at home. Another reason given for delaying the age of introduction of Incaparina to 12 months was the belief that Incaparina was a strong drink that would cause irritation or infection in a young infant's stomach. A few mothers

TABLE 2. Use of, preparation of, and traditional beliefs about Incaparina by caretakers according to survey

Characteristic	Santa María de Jesús ($n = 50$)	Mezquital ($n = 50$)	p^a
Consumption by other family members—no. (%)	49 (98)	50 (100)	NS
Children never given Incaparina—no. (%)	8 (16)	10 (20)	NS
Monthly use			
Mean no. of days/mo prepared	12.3	15.0	NS
Prepared daily—no. (%)	15 (30)	17 (34)	NS
Children 6–23 mo of age given Incaparina—no. (%)	42 (84)	40 (80)	NS
Age (mo) of introduction of Incaparina—no. (%) of children			
1	6 (14)	0 (0)	
2	4 (10)	1 (3)	
3	4 (10)	3 (8)	
4[b]	3 (7)	2 (5)	
5	3 (7)	3 (8)	
6	9 (21)	11 (27)	
7–12	11 (26)	19 (47)	
≥ 13	2 (5)	1 (3)	
Mean ± SD age of introduction (mo)	5.7 ± 7.6	7.2 ± 7.2	NS
Feeding method—no. (%)			
Bottle	14 (33)	35 (88)	.0001
Cup	27 (64)	5 (12)	
Mean consumption on days when Incaparina was prepared—ml	179.7	383.3	.002
Children with diarrhea given Incaparina—no. (%)	29 (58)	25 (50)	NS
Standard amounts of other ingredients for 75 g of Incaparina			
Water (ml)	1,822	1,358	.0001
Sugar (g)	127	75	.0001
Consistency of Incaparina—no. (%)			
Children 6–23 mo of age ($n = 82$)			
Thin (like water)	25 (60)	30 (75)	
Thicker than water	17 (40)	10 (25)	NS
Family members > 23 mo of age			
Thin (like water)	26 (52)	21 (42)	
Thicker than water	24 (48)	29 (58)	NS
Beliefs about Incaparina—no. (%)			
Hot food	41 (82)	40 (80)	
Cold food	4 (8)	8 (16)	
Neither hot nor cold	5 (10)	2 (4)	NS

a. Chi-square test. NS indicates not significant ($p > .05$).
b. Age of introduction for children 4 months of age and younger differed significantly between communities ($p = .01$).

believed that it was better to begin feeding Incaparina at around 4 months of age so that the child's stomach would become accustomed earlier to digesting Incaparina. Reasons given for using Incaparina were that it was affordable, had a high nutritional content, and alleviated hunger throughout the day.

The utensils used to serve Incaparina to children differed between the two sites (table 2). The majority (88%) of caretakers in Mezquital used a bottle to feed Incaparina to their youngest children, whereas 64% in Santa María de Jesús used a cup. On average, children in Mezquital reportedly consumed twice as Incaparina per day as those in Santa María de Jesús (383.3 vs 179.7 ml). Among the 18% of women who had never given their youngest child Incaparina, 67% believed that the child was too young or that Incaparina could cause an infection because the child's stomach was not strong enough to handle this kind of food.

The majority (54%) of caretakers surveyed continued to give their children Incaparina when they had diarrhea (table 2). The reasons given for continuing to feed Incaparina were that Incaparina would not worsen their child's diarrhea (52%), Incaparina helped the child get rid of the diarrhea (26%), Incaparina helped the child rehydrate (8%), Incaparina alleviated hunger (6%), and the child wanted Incaparina (7%). Additional reasons were that Incaparina was good for the child because it had many vitamins or alleviated stomach pains. Those caretakers who would not give Incaparina to a child with diarrhea indicated that Incaparina would worsen the child's diarrhea and/or cause more infection (78%), or that the child had no appetite (16%). These reasons were also mentioned by the focus-group participants.

Preparation of Incaparina

Recommended directions for preparing Incaparina are printed on the back of the package. According to the directions, 75 g of Incaparina should be mixed with 1,000 ml of water and boiled for at least 15 minutes; sugar, salt, and cinnamon may be added for taste. The caretaker survey found that the average amount of water used for 75 g of Incaparina was 1,590 ml, or about one and a half times the recommended amount, and the average amount of sugar used was 100 g (table 2). The caretakers in Santa María de Jesús used significantly more water and sugar than those in Mezquital.

Among those caretakers who prepared Incaparina for children 6 to 23 months of age, 67% preferred to prepare it with a consistency similar to that of water. For family members older than 23 months, 47% of caretakers preferred to prepare Incaparina with a consistency similar to that of water. The reasons given for preparing Incaparina with a particular consistency

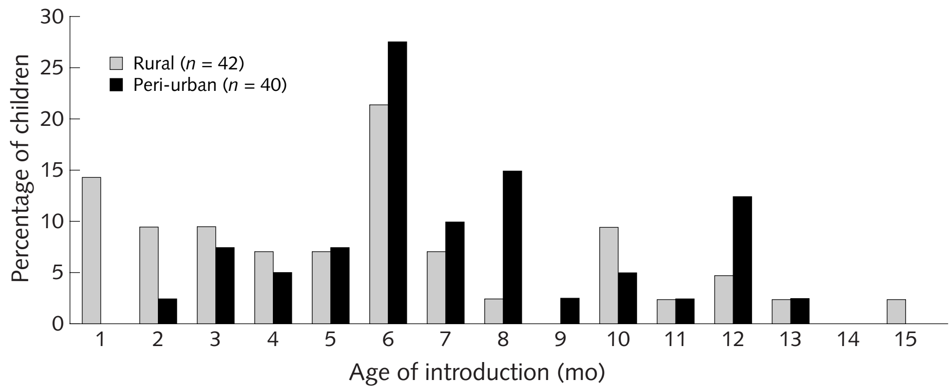

FIG. 1. Age of introduction of Incaparina

are listed in table 3. When asked about their preferred consistency of Incaparina, the focus-group participants gave similar comments.

Beliefs about Incaparina

Traditional beliefs about hot and cold foods were found to be prominent throughout the communities (table 2). Incaparina was considered a hot food by 81% of caretakers. Of those, 48% considered it hot because it warmed the body as it was being drunk, 34% because it gave children diarrhea, and 11% because it contained a lot of vitamins (data not shown). The caretakers in the focus-group discussions expressed similar reasons. Of those surveyed who considered Incaparina a cold drink, 50% said they felt refreshed after drinking it, 42% believed that Incaparina would not cause infection in healthy children or make them

TABLE 3. Number and percentage of caretakers reporting various reasons for preparing Incaparina with thin, waterlike consistency or thicker consistency for children 6 to 23 months of age or for older family members[a]

Consistency and reasons	Santa María de Jesús	Mezquital
Children 6–23 mo		
Thin consistency (n = 55)		
Incaparina easily passes through bottle nipple without clogging	14 (26)	14 (26)
Caretaker believes the child does not like to drink Incaparina with a thick consistency	9 (16)	14 (26)
Will not cause harm or infection if prepared with a thin consistency	2 (4)	1 (2)
Child's stomach would feel full	1 (2)	2 (4)
Thick consistency (n=27)		
Child likes Incaparina with a thicker consistency	7 (26)	2 (7)
Child's stomach will be full	7 (26)	6 (22)
Child will gain weight	1 (4)	1 (4)
Higher concentration of vitamins in each serving	1 (4)	0 (0)
Will not cause harm or infection if prepared with a thicker consistency	2 (7)	0 (0)
Older family members		
Thin consistency (n = 47)		
Family prefers waterlike consistency	19 (40)	13 (28)
Better flavor	2 (4)	7 (15)
Can be drunk easily and quickly	4 (9)	1 (2)
Incaparina prepared every day	1 (2)	0 (0)
Thick consistency (n = 53)		
Diminishes feelings of hunger for longer period	2 (4)	11 (21)
Better flavor	8 (15)	6 (11)
Family prefers consistency thicker than water	6 (11)	3 (6)
Contains more vitamins and helps with lactation	4 (8)	1 (2)

a. The reasons are not mutually exclusive.

TABLE 4. Caretakers' judgments of organoleptic characteristics of Incaparina (number and percentage of caretakers)

Characteristic	Santa María de Jesús ($n = 50$)	Mezquital ($n = 50$)
Taste		
Good	50 (100)	50 (100)
Bitter	16 (32)	15 (30)
Sweet	12 (24)	6 (12)
Unique	38 (76)	46 (92)
Similar to other atoles[a,b]	12 (24)	4 (8)
Smell		
Good	47 (94)	48 (96)
Bitter	0	3 (6)
Unique	44 (88)	47 (94)
Similar to other atoles[a,b]	3 (6)	4 (8)
Color		
Good/nice	26 (52)	45 (90)
Yellow	32 (64)	13 (26)
Coffee	16 (32)	34 (68)
Unique	38 (76)	43 (86)
Similar to other atoles[a,b]	12 (24)	7 (14)
Quality most liked		
Flavor	44 (88)	46 (92)
Smell	3 (6)	2 (4)
Color	0 (0)	0 (0)
Thickness	3 (4)	2 (4)

a. Other atoles include *atol de haba* (broad bean), *atol de trigo* (wheat), *Bienestarina* (soybean flour), *Trece Cereales* (13 cereals), *soya* (soy), and *mosh* (oatmeal).
b. The responses were not mutually exclusive.

ill, and 8.3% said that Incaparina gave children a stomachache (data not shown).

Acceptance of Incaparina

Several questions were asked about Incaparina's organoleptic characteristics (table 4). Overall, the perceptions were very favorable. Every caretaker thought that Incaparina had a good taste, although when asked to describe the flavor, 31% thought it had a bitter flavor. Ninety-five percent thought that Incaparina had a pleasant smell. The smell was described as chocolate, garlic, corn, bitter, milk, wet, smooth, or soapy. Seventy-one percent stated that Incaparina had a nice color. One-half of the caretakers described the color of Incaparina as coffee and 45% as yellow. The quality of Incaparina that the caretakers liked the most was its flavor. A majority of the respondents thought that Incaparina was different from any other product they consumed in its taste (84%), smell (91%), and color (81%)(data not shown). High acceptability was also found in the focus-group discussions, in which the participants highly approved of Incaparina's organoleptic characteristics and gave comparable responses to the participants in the caretaker survey.

Recommendations for use by health professionals

The health clinic doctors in Santa María de Jesús recommended that mothers breastfeed their children and begin to give them Incaparina, along with vegetables and fruit, after six months of age. The doctor at the government-funded health clinic recommended that children over 12 months of age be given one cup of Incaparina every day to help the them grow and stay healthy. The doctor at the dispensary recommended that children should not be given Incaparina while they had diarrhea, and that feeding with Incaparina should be resumed after the child had been treated with oral rehydration therapy and the diarrhea began to go away. The doctor at the dispensary also thought that many caretakers did not like giving young children (under two years of age) Incaparina because they believed it would make them sick. Consequently, the dispensary recommended preparing Incaparina with a consistency similar to that of water for the first 15 days of use and with a thicker consistency thereafter. The doctor believed that this would allow the child's system to adapt to Incaparina and would also make the caretaker feel more comfortable.

The nurses at the main health center in Mezquital advised all mothers to give their children Incaparina, beans, fruit, and vegetables three times a day, beginning at five months of age. They recommended that caretakers prepare Incaparina on a daily basis with a consistency thicker than water; however, for a child who was sick with diarrhea, they advised the mother to prepare Incaparina with a consistency similar to that of water. The nurses believed that Incaparina would be too strong for the child's stomach and would make the diarrhea worse.

Cost

There were no significant differences between the communities in the cost of Incaparina as reported by the caretakers (table 5). In March 1999, according to the caretakers, the average cost of a 454-g bag of Incaparina was 3.73Q (US$0.55), and the range was from 3.00Q (US$0.44) to 6.00Q (US$0.90). The average cost of a 75-g bag was 1.16Q (US$0.17), and the range was from 1.00Q (US$0.15) to 2.00Q (US$0.30). Eighty-one percent of the caretakers considered Incaparina to be an inexpensive to moderately priced food.

There also were no significant differences between the communities in the cost of Incaparina as reported by the store owners. The average cost of a 454-g bag was 3.50Q (US$0.52), and the range was from 3.00Q (US$0.45) to 4.00Q (US$0.60). The average cost of a 75-g bag was 0.91Q (US$0.14), and the range was from 0.75Q (US$0.11) to 1.25Q (US$0.15) for both communities.

TABLE 5. Cost and sales of Incaparina[a]

Variable	Santa María de Jesús	Mezquital	*p*
Costs reported by caretakers			
454 g			
Mean	3.72Q (US$0.55)	3.74Q (US$0.55)	NS
Range	3.00–5.00Q	3.00–6.00Q	
75 g			
Mean	1.27Q (US$0.19)	1.07Q (US$0.16)	NS
Range	1.00–2.00Q	1.00–2.00Q	
Costs reported by store owners			
454 g			
Mean	3.55Q (US$0.53)	3.42Q (US$0.51)	NS
Range	3.25–4.00Q	3.00–3.75Q	
75 g			
Mean	0.88Q (US$0.13)	0.94Q (US$0.14)	NS
Range	0.75–1.00Q	0.80–1.25Q	
Caretakers' opinion of cost—no. (%)			
Inexpensive	20 (40)	22 (44)	NA
Moderate	22 (44)	17 (34)	
Expensive	8 (16)	11 (22)	
No. of packages sold each month by store owners			
454 g			
Median	25	60	NS
Range	1–50	18–400	
75 g			
Median	28	20	NS
Range	5–50	3–100	

a. Q, Guatemalan Quetzal; NS, not significant ($p > .05$); NA, not applicable.

Amount of Incaparina sold

Most store owners sold Incaparina in both the 75-g and the 454-g bags. The median numbers of bags sold each month per store were 25 454-g bags and 20 75-g bags (table 5). Seventy percent of store owners said that Incaparina was the atole most frequently sold; they believed that most people bought Incaparina because of its flavor.

Discussion

This paper has reported the use of, beliefs about, and acceptability of an industrially produced, vegetable-based food, Incaparina, among caretakers of children aged 6 to 23 months in Guatemala; the cost and amount of Incaparina sold each month in local stores; and the recommendations of local health clinic personnel concerning the use of Incaparina during a child's first two years of life. The results indicate broad and frequent use and a high acceptance as measured by taste, smell, and color, a preference for preparing Incaparina with a thin consistency, and an earlier age of introduction to Incaparina in the rural community.

The consumption of Incaparina by families in Guatemala has increased since the mid-1960s. In the current study, nearly 100% of families and 82% of children under two years old consumed Incaparina. Caretakers prepared Incaparina on an average of 13.7 days per month, which was more frequently than expected. An acceptability trial in 1965 in Guatemala found that 45% of families in the trial consumed Incaparina and that 79% of these families stated that they served Incaparina to all family members.* Another acceptability trial conducted in Guatemala by Méndez-Domínguez in 1968 reported that 80% of families and 73% of children under two years old consumed

* Shaw RL. The marketing of Incaparina. An unpublished report to the WHO/FAO/UNICEF Protein Advisory Group. pp 2–19.

Incaparina [18]. Thus, the current acceptability trial found a higher consumption by families and children than previous trials, but the difference might be due to the communities studied.

The consumption of Incaparina by children reportedly decreased when they were sick with diarrhea. However, over half of the caretakers (54%) continued to give Incaparina to children under two years old with diarrhea. Schroeder et al. also found that mothers in Santa María de Jesús had different opinions about feeding Incaparina to children with diarrhea [21]. Thirty-four percent of the caretakers considered Incaparina a hot food because it could cause diarrhea in children. It is possible that the caretakers continued to feed their children Incaparina because of its nutritional benefits, even though they believed it could cause diarrhea.

Industrially processed foods have been widely accepted for their taste, smell, and color. Preliminary results from a baseline acceptability survey in Mexico showed promising results with an industrially processed food called *papilla* that was given to children under two years of age and moderately underweight children between two and three years of age [Rivera J, personal communication, 2000]. The average score for *papilla* ranged between 4.0 and 4.1 over a five-point hedonic scale. The current study demonstrated that caretakers overwhelmingly accepted Incaparina, particularly its taste (100%) and smell (95%). These results are similar to the Méndez-Domínguez study, which found that over 90% of respondents reported positive perceptions when asked about Incaparina's organoleptic characteristics [18]. Fewer caretakers (71%) had favorable opinions of Incaparina's color. This could be due to Incaparina's brownish-yellow color. Favorable results such as these are promising for the potentially widespread acceptability and use of industrially processed foods based on local preferences.

Caretakers had well-defined notions of food consistency when preparing foods for young children. Most caretakers (67%) preferred to prepare Incaparina with a consistency like that of water for children under two years old. When preparing Incaparina, the caretakers used one and a half times the recommended amount of water, which lowered the energy density of Incaparina by one-third. A study in Peru found that caregivers generally selected more dilute preparations as first foods for their infants [23]. A previous study in Santa María de Jesús showed that 67% of mothers complained that the consistency of Incaparina was too thick when it was prepared according to package instructions and often used much more water than was called for [21]. Conversely, an earlier study in Santa María de Jesús found that only 27% of mothers preferred to prepare Incaparina with a thin, waterlike consistency for children under two years old [19, 20]. This preference decreased to about 13% for children with diarrhea. Differences in the understanding and definition of consistency by caretakers could explain the incongruous results between studies.

Contaminated feeding devices and inadequate storage are important causes of diarrhea in developing countries [4]. The current study found that a large majority (88%) of caretakers in Mezquital served Incaparina in a bottle and that caretakers made large amounts of Incaparina and stored it over several days. Household studies in Peru found that the rates of contamination were considerably higher in preparations given to children in feeding bottles than in those given in cups [24]. The same studies also found that bacterial contamination increased with increased duration of storage [23, 25].

In both communities, and especially in the rural community, many mothers introduced Incaparina earlier than the World Health Organization (WHO) recommendation of about six months of age. Early introduction of foods is common in Santa María de Jesús and Guatemala; a previous study in Santa María de Jesús found that 6% of mothers introduced Incaparina and 18% to 39% of mothers introduced foods such as grain beverages, barley water, black coffee, bread, and sweet water before five months of age [21]. It should be noted that the early introduction of non-breastmilk foods is common in Santa María de Jesús and that Incaparina is not the only food being introduced earlier than the WHO suggestion.

Recommendations by health professionals differed between communities and were sometimes contradictory to the Guatemalan Ministry of Health regulations. The Ministry recommends that children with diarrhea should be given oral rehydration therapy, should continue breastfeeding, and, if they are already being given complementary foods, should be given foods such as Incaparina with high nutrient content.

The manufacturers may introduce a new formula for Incaparina soon. Because of the shortage of suitable cottonseed flour and its increased cost, the producer will be substituting soy flour for cottonseed flour and increasing the amounts of minerals, particularly zinc and iron (table 6) [25]. Although its formula suggests that it will be of comparable nutritional value to the current product, this should be confirmed by feeding studies with animals or humans.

TABLE 6. Nutritional composition of original and new Incaparina: quantities of nutrients and percentages of the recommended daily allowance (RDA) for children one to three years of age in one ration of Incaparina

Nutrient	RDA	Original Incaparina[a]	New Incaparina
		Quantity per ration[b] (% of RDA)	
Calories—kcal	1,300	69 (5.5)	100 (7.5)
Protein—g	21	4.3 (21)	4.4 (21.5)
Vitamin A—RE	400	256 (64)	100 (25)
Niacin—mg	8	2.5 (32)	2.8 (35)
Thiamin—mg	0.5	0.3 (60)	0.16 (32)
Riboflavin—mg	0.6	0.2 (33)	0.22 (36.5)
Vitamin B_{12}—µg	0.5	—	0.2 (40)
Folic acid—µg	40	—	40 (100)
Zinc—mg	8	—	2.8 (35)
Iron—mg	10	2.1 (21)	4.8 (48)
Calcium—mg	400	57.2 (14)	200 (50)
Phosphorus—mg	300	12.2 (4)	—
Key ingredients		Maize flour (65%), cottonseed flour (25%), soybean flour (10%)	Maize flour (70%), soybean flour (30%)
Energy density (kcal/g)			
Dry product		3.67	5.33
Water added		0.27	0.40
Water and sugar added		0.58	0.69
Ration size per day (g)			
Dry product		18.75	18.75
Volume of ration with water added (ml)		250	250
Suggested no. of servings per day		4	4
Energy per day (kcal)		69	100
Cost (US$)			
Per ration		0.018	0.02
Per 100 g		0.10	0.11
No. of rations per package		24	24
Cooking time		At least 15 min	10 min

Source: ref. 25.

a. The formula for Incaparina as first marketed was 38% cottonseed flour, 3% torula yeast, 58% whole ground corn or a mixture of whole ground corn and sorghum, and 1% calcium carbonate [26].

b. A ration consists of 250 ml prepared Incaparina or 18.75 of flour.

Recommendations and future research needs

As the result of this study, we make the following recommendations. Health education classes should be given to teach caretakers how to properly introduce, prepare, and serve Incaparina to their children. Health professionals should encourage continued feeding with Incaparina during diarrheal episodes. Because changes in the ingredients of Incaparina could change its taste, smell, or color, new formulations should be studied for acceptance under current conditions of use before commercial introduction.

In conclusion, Incaparina is widely accepted and frequently consumed by Guatemalan children and families. The high use and frequency of preparation of Incaparina suggest that industrially produced, low-cost mixtures like Incaparina can be widely accepted and may be a good vehicle for improving dietary intake and nutritional status. The current study identified positive patterns of use and practices that can be improved (e.g., improved serving utensils and storage, and avoidance of introducing Incaparina too early) and positive perceptions that can be used for further promotion of Incaparina (e.g., taste and nutritional value). With continued higher use and consumption by the Guatemalan population, Incaparina can continue to contribute to significantly improving the dietary intake and nutritional well-being of young children. If the new formula proves equally acceptable, this will ensure continued supply of the ingredients and better cost control.

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Nonglyceride components of edible oils and fats. 1. Chemistry and distribution

B. S. Narasinga Rao

Abstract

Dietary fats and oils are essentially glycerides of fatty acids (triglycerides), which account for 90% to 98% of their mass. The remaining 2% to 10% consists of fat-soluble phytochemicals derived from oil-bearing seeds, nuts, or fruits. These nonglyceride components of fats and oils represent a wide range of chemical classes, such as sterols, terpene alcohols, tocopherols, hydrocarbons, long-chain alcohols including waxes, carotenoid pigments, and sulfur- and nitrogen-containing flavor compounds. Each of these classes of chemicals consists of a number of different compounds. Their number and type and the quantity present vary from one oil to another. Modern analytical tools developed in recent decades have enabled separation and identification of the individual chemicals of each class in a number of oils. The nonglyceride chemical components of oils pass into the unsaponifiable fraction as such or in a modified form. There is still a gap in our knowledge concerning the identity and nature of several of these chemicals in the nonglyceride components, particularly in some of the unconventional edible oils. Earlier, these nonglyceride components were considered adventitious chemicals. For the past two decades, however, it has been recognized that many of them have nutritional and physiological functions that have been proved by animal and human studies to be useful in preventing noncommunicable diseases and promote health. The nonglyceride components of edible oils (i.e., palm, rice bran, and sesame oils) are particularly rich in such health-promoting chemicals.

Introduction

Fats and oils, which are essentially triglycerides of fatty acids, are important components of the human diet, providing energy and essential fatty acids (fig. 1).

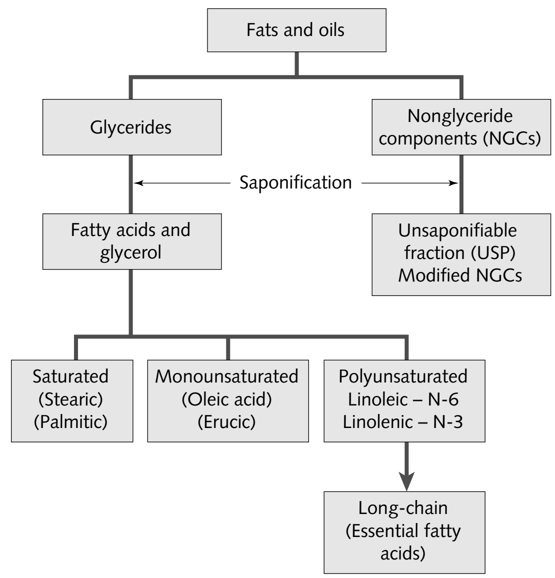

FIG. 1. Fats and oils and their components

Excess fat intake (> 30 en%), particularly of saturated fats, is also known to be a health hazard, since it is a predisposing factor in the causation of obesity and cardiovascular disease. Besides the fatty acids that exist as triglycerides and complex lipids, which account for 92% to 99% of their content, edible oils and fats also contain other fat-soluble chemicals (phytochemicals) derived from oil-bearing seeds and fruits, which account for 1% to 8% of their content [1]. These fat-soluble chemicals, collectively designated *nonglyceride components*, are extracted along with oils and fats. These chemicals belong to a wide range of chemical species, such as sterols, terpene alcohols, tocopherols, hydrocarbons, long-chain alcohols including waxes, carotenoid pigments, and sulfur- and nitrogen-containing flavor compounds (table 1). These nonglyceride compounds have been shown to possess distinct nutritional and physiological functions.

Much research has been done during the past two decades to identify the individual nonglyceride com-

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TABLE 1. Nonglyceride components of fats and oils

Natural hydrocarbons	Squalene, short- and long-chain hydrocarbons, waxes
Sterols	Phytosterols, cholesterol
Alcohols	Aliphatic and terpenoic alcohols
Tocols	Tocopherols and tocotrienols
Phenolic compounds	Saponins, gossypol
Carotenoids and other pigments	β- and other carotenes
Sulfur and nitrogen compounds	Glycosylated alkaloids, isothiocyanates
Complex lipids	Phospholipids, sphingosine, diacylglyceride ethers, glucolipids

ponents of several common edible oils. However, our knowledge of the identity of several of these compounds and the molecular mechanisms underlying their known physiological functions is still incomplete. Several minor oils that have been shown to be safe to eat also contain a fairly high level of nonglyceride components whose chemical nature and bioactivity have yet to be established, and this is a potential area for research. Present knowledge of the nonglyceride components of oils and fats and their chemical nature is reviewed and discussed here, and their biological functions are discussed in part 2 of this article [2].

Nonglyceride components (unsaponifiable matter) in fats and oils

Before the 1950s, not much attention was paid to the individual nonglyceride components or the unsaponifiable fraction of oils, except for some of the major compounds, such as steroids, which were separated by classical methods. With the advent of diverse chromatographic techniques, such as column chromatography, gas chromatography, reverse-phase chromatography, and high-performance liquid chromatography, the individual nonglyceride components of a number of oils and fats have been separated, identified, and quantified. These nonglyceride components can be directly separated and isolated in an unmodified original form from the oil or fat directly through solvent partition, molecular distillation, and adsorption and liquid-partition chromatography. The classes of compounds currently reported to be present in the nonglyceride components of oils and fats are given in table 1. Some details concerning their chemical properties are briefly described below.

The nonglyceride component or unsaponifiable fraction content varies from oil to oil, as shown in table 2. In most oils it constitutes 1% or less of the content, but in some oils it may range from 2% to 8%. The unsaponifiable fractions in oils from cereals such as wheat, rice, and maize and in some unconventional oils are fairly high. At the normal level of dietary fat intake, the fats and oils that contain more than 2% unsaponifiable matter can contribute significantly to the intake of these compounds present in the nonglyceride components. Several of these compounds present in the crude oil from oil-bearing seeds, nuts, or fruits may be destroyed, reduced in concentration, or chemically modified during the steps normally employed in the refining process.

The classes of chemicals present in the unsaponifiable fraction of some of the well-known vegetable oils are given in table 3. Sterols constitute a major part of the unsaponifiable fraction in most of the oils, followed by terpene alcohols, aliphatic alcohols, squalene, and hydrocarbons. Tocopherols, carotene pigments, and flavor compounds are only minor components.

Sterols

Sterols, the major component of the unsaponifiable fraction in most oils, are all phytosterols. Cholesterol is present mostly in animal fats, but small amounts are present in a few vegetable oils. There are usually

TABLE 2. Unsaponifiable fraction (USF) in different vegetable oils

Low USF (< 1.3%)		High USF (1.5%–5.0%)		Unconventional oils	
Oil	USF (%)	Oil	USF (%)	Oil	USF (%)
Cocoa butter	0.9	Rice bran	4.1	Mango kernel	7.4
Coconut	1.2	Wheat germ	5.0	*Terminalia bellarica*	8.2
Cottonseed	1.5	Sesame	2.0	Kokum	2.3
Groundnut	1.8	Olive	2.5	Sheanut	4–8
Palm	1.2	Mustard	2.0	*Cleum viscosa*	2.0
Palm kernel	0.8	Soybean	1.6	Mahua	1.1
Sunflower	1.3	Corn	2.8	Illipe	2.0
Linseed	1.7	Kapok seeds	1.0		
Safflower	1.3	Groundnut	1.8		

three to four phytosterols in all oils: brassicasterol, campesterol, stigmasterol, and β-sitosterol. β-Sitosterol is a major component found in all oils. The sterol composition of oils and fats and their chemical nature have been worked out in great detail by gas chromatography, nuclear magnetic resonance, reversed-phase high-performance liquid chromatography, gas chromatographic mass spectroscopy, etc. Sterols and their contents are given in table 4. A number of minor sterols have also been separated and identified [3]. Besides the normal sterols, three types of minor sterols—4-desmethyl, 4-monomethyl, and 4,4′-dimethyl sterols—are also reported to be present in some of the edible oils [3]. The dimethyl sterols, derivatives of terpenes, are also described as cyclic terpene alcohols. Vegetable oils vary widely in their content of sterols of different groups and their relative proportions [3] (table 4). Some phytosterols, when present in the diet, are reported to be hypocholesterolemic [4], and they act by competitively inhibiting the absorption of dietary cholesterol.

TABLE 3. Unsaponifiable composition (percent) of some well-known vegetable oils

Oil	Hydro-carbons	Squalene	Aliphatic alcohols	Terpene alcohols	Sterols
Olive	2.8–3.5	32–50	0.5	20–26	20–30
Rape seed	8.7	4.3	7.2	9.2	63.6
Corn	1.4	2.2	5.0	6.7	81.3
Soybean	3.8	2.5	4.9	23.2	58.4
Linseed	3.7–14.0	1.0–3.9	2.5–5.9	29–30	31.5–52.0
Tea-seed	3.4	2.6	—	—	22.7
Rice bran	7.0	—	—	24.0	42.0

TABLE 4. Sterols and triterpenes in different edible oils (mg/100 g)

Oil	Campe-sterol	Stigma-sterol	β-Sito-sterol	Total no. of sterols[a]
Rice bran	5.06	271	885	6
Safflower	45	31	181	8
Corn	410	110	1,180	9
Sunflower	31	31	235	8
Cottonseed	17	4	400	6
Sesame	117	62	382	6
Soybean	72	72	191	7
Groundnut	36	21	153	5
Olive oil (crude)	7	3	202	6
Palm	23	14	72	5
Coconut	8	21	77	4
Rapeseed	156	2	284	13

a. Including minor sterols and cyclic terpene sterols.

Terpene alcohols

The study of terpene alcohols [5], dating back to 1957, was somewhat facilitated by the knowledge then available about the analogous components of essential oils and natural resins. Terpene alcohols in vegetable oils are present partly in free form and partly as esters, and little is known about the fatty acids that esterify the terpene alcohols [6]. Besides ferulic acid, the other fatty acids are presumed to be the same as those in the triglycerides. In the unsaponifiable matter, however, they are present as free alcohol. The number of cyclic terpene alcohols present in edible oils varies from 4 to 13. The components identified so far belong exclusively to three groups: acyclic terpenes and cyclic di- and triterpenes [7]. The most widely present cyclic terpenes, cycloarterenol and 24-methylene cycloarterenol, are present in significant amounts in rice bran oil, wheat germ oil, soybean oil, linseed oil, and olive oil (table 5). Other cyclic terpenes are α- and β-amyrin, cycloartarnol, butyrospermol, euphorbol, and cyclolaudenol. The biological significance of these cycloarterenols is that they are reported to be strong hypocholesterolemic agents, as studies with rice bran oil have shown. Other terpene alcohols identified in oils are the two acyclic terpene alcohols phytol and geranylgeraniol, which may be a precursor of di- and tricyclic terpenes and of some forms of carotenes, including lycopenes.

Tocopherols (vitamin E)

Tocopherols are present in all vegetable oils to a varying extent; the richest sources are wheat germ and palm oils. These tocopherols can be separated by gas-liquid chromatography, column chromatography, or thin-layer chromatography. Because of the poor stability of tocopherols in the presence of air, special precautions have to be taken in the separation and quantitation

TABLE 5. Cyclic terpenes in different edible oils (mg/100 g)

Oil	Cyclo-artarnol	Cyclo-arterenol	24-Methylene cyclo-arterenol
Rice bran	106	482	494
Safflower	1	34	7
Corn	4	8	11
Sunflower	—	29	16
Cottonseed	—	10	17
Sesame	4	62	107
Soybean	—	168	8
Groundnut	1	11	16
Olive (crude)	1	18	31
Palm	2	60	34
Coconut	2	55	22
Rapeseed/mustard	1	54	14

of tocopherols. Besides tocopherols, some vegetable oils also contain tocotrienols, which are analogues of tocopherols. Tocotrienols are present in palm oil in similar concentrations as tocopherols and, to a lesser extent, in some other oils, such as rice bran oil. There are four tocopherol isomers: α, β, γ, and δ. The tocopherol and tocotrienol contents of vegetable oils are shown in table 6. Tocopherols and tocotrienols have a significant role in human and animal nutrition as "vitamin E." Both tocopherols and tocotrienols are potent antioxidants and can protect against degenerative diseases, such as cancer and atherosclerosis, that are caused by free-radical damage [8].

Carotenes

Although carotenes and other carotenoids may be present in small quantities or only in traces in many oils, crude palm oil is the richest source of carotenes, with a concentration of nearly 700 to 800 ppm, of which about 400 to 500 ppm is β-carotene. These carotenes in the nonglyceride components of crude red palm oil are destroyed during refining of the crude oil. The β-carotene of crude palm oil is a rich source of provitamin A [9], and all the carotenes present in red palm oil have antioxidant potential [10]. With realization of the nutritional and health-promoting potential of carotenes, appropriate processes have been developed to manufacture edible-grade red palm oil from crude palm oil, in which most of the carotenes (500 ppm) present in the crude oil are preserved [11, 12]. Carotene concentrates have also been prepared from crude red palm oil by molecular distillation. There is a need to develop a suitable process for refining crude palm oil by which the carotenes present in crude oil can be recovered in their natural form. Carotenes present as the nonglyceride components in oils will not remain intact during saponification. Therefore, other methods should be used to extract carotenes directly from the oil, employing suitable separation methods.

Aliphatic alcohols

The alcohols present in the nonglyceride component or unsaponifiable fraction of oils are water-insoluble, long-chain higher alcohols (table 1). A series of at least eight components of straight-chain alcohols, C_{12} to C_{32}, has been identified, and so far no branched-chain or unsaturated alcohols have been reported to be present in oils [1]. The alcohol content of oils may vary from 0.5% to 7% of the unsaponifiable fraction (table 3). No bioactivity has so far been attributed to the aliphatic alcohols. A mixture of ferulic acid esters of sterols and triterpene alcohols present in rice bran oil, designated "oryzanol," is reported to be a hypocholesterolemic agent [13].

Hydrocarbons

The classes of hydrocarbons present in vegetable oils include paraffins (normal and branched-chain), terpenoids (squalene and its homologues), and polycyclic aromatic compounds. There are numerous paraffins in vegetable oils. Several other hydrocarbons are reported to be present in the nonglyceride components of oils and fats, but their presence needs confirmation. Hydrocarbons constitute 1.4% to 14.0% and squalene 2.2% to 50% of the unsaponifiable matter (table 3). The highest content of squalene is present in olive oil, where it forms 30% to 50% of the unsaponifiable fraction, the actual quantity being 400 to 700 mg per liter. The biological action of these hydrocarbon components is not yet known, but squalene may have some biopotency. Isoprenoid-related terpenoids may have the power to inhibit cholesterol synthesis in the body [14].

Nitrogen- and sulfur-containing compounds

Among the nonglyceride components of fats and oils, there are certain compounds that have antinu-

TABLE 6. Tocopherol and tocotrienol fractions in vegetable oils (μg/100 g)

Tocols	Palm oil	Rice bran oil	Soybean oil	Safflower oil	Corn oil	Peanut oil
Total tocopherol	642	181	958	801	782	369
α-Tocopherol	256	61	101	378	112	130
β-Tocopherol	—	Trace	—	—	150	—
γ-Tocopherol	316	111	593	174	602	216
δ-Tocopherol	70	9	244	240	18	21
Total tocotrienol	492	369	—	—	—	—
α-Tocotrienol	143	49	—	—	—	—
β-Tocotrienol	32	292	—	—	—	—
γ-Tocotrienol	286	28	—	—	—	—
δ-Tocotrienol	69	—	—	—	—	—

tritional or toxic properties; these compounds are listed in table 7. Such compounds include the gossypol group of compounds; sulfurated glucosides, such as glucosinolates, which are present in mustard seeds and rapeseeds (Cruciferae Family) and which on enzymatic (myrosinase) hydrolysis yield isothiocyanates; and oxazolidinthiones, goitrogens present in normal mustard and rapeseed oils. These isothiocyanates also possess antioxidant properties. There is a very toxic alkaloid present in argimone oil that is used for adulterating mustard oil and whose consumption leads to epidemic dropsy [15]. Other toxic compounds, the saponins, are present in soybean and peanut oils. These toxic and antinutritional compounds, if present in edible oil, must be removed to make the oil safe for human consumption. Saponin, similarly to digitonin, may bind with cholesterol to form insoluble complexes.

Sesamin, sesamolin, and other phenolic substances

Sesame oil, from the oil seed *Sesame indicum,* is one of the two oldest edible oils known to humans [16]. It was used in ancient India. The nonglyceride components of sesame oil contain unusual minor components—sesamin, sesamolin, and sesamol—which exhibit more unusual chemical and physiological properties than any other nonglyceride components in common edible oils [17]. The structures of these three compounds are shown in figure 2. Sesame oil contains about 2% to 3% unsaponifiable matter, consisting of sterols and other compounds in addition to sesamin, sesamolin, and sesamol. The native oil contains predominantly sesamin and sesamolin and a small amount of sesamol. Sesamin can exist in different isomeric forms depending on the R group in its molecule. The sesamin content of sesame oil is reported to vary between 0.5% and 1.0%. Sesamolin is a methylene ether of oxyhydroquinone and on hydrolysis yields sesamol, a phenolic compound that is a powerful antioxidant (fig. 2). Neither sesamolin nor sesamin has been found to possess any appreciable antioxidant activity [17]. Sesame oil is reported to contain 0.3% to 0.5% sesamolin and only traces of free sesamol. During processing sesamol may be released, providing 0.1% sesamol in bleached and hydrogenated sesame oil. Sesamolin may be partly lost during processing. Sesame oil, due to the presence of sesamol, a powerful antioxidant, is a highly stable oil. It is used in other oils and hydrogenated fats as a stabilizer, as well as a marker that can be identified by the Budoin test.

Sesamol is released in the gut from sesamolin and can serve as an antioxidant. Sesame oil is a unique edible oil that contains sesamolin, whose breakdown product is sesamol, a powerful antioxidant. Sesamin is also reported to be a hypocholesterolemic agent that inhibits synthesis of cholesterol from acetate in the body [18].

TABLE 7. Some toxic compounds in vegetable oils and their biological effects

Compound	Toxic effects	Beneficial effects
Sulfur compounds		
Isothiocyanates	Goitrogen	Antioxidant
Oxazolidinthiones		Antioxidant
Glucosinolates		Antioxidant
Alkaloids		
Sanguinarine	Toxic	
Gossypols	Toxic	Antioxidant
Saponins	Toxic	Hypocholesterolemic

Other minor compounds

Besides the above well-identified chemical compounds, the nonglyceride components of several edible oils are known to contain a large number of minor compounds that may not have any biological significance. These minor components may belong to the groups of substances described above. There are also several minor unconventional oils that have been shown to be safe to eat [19]. These oils are also reported to contain high levels of unsaponifiable matter at concentrations of 6% to 8% (table 2). The nonglyceride components of these oils have not been fractionated, and the chemical compounds present have not been identified nor their biological activity studied. They may contain biologically active health-promoting components. This is an area for future research.

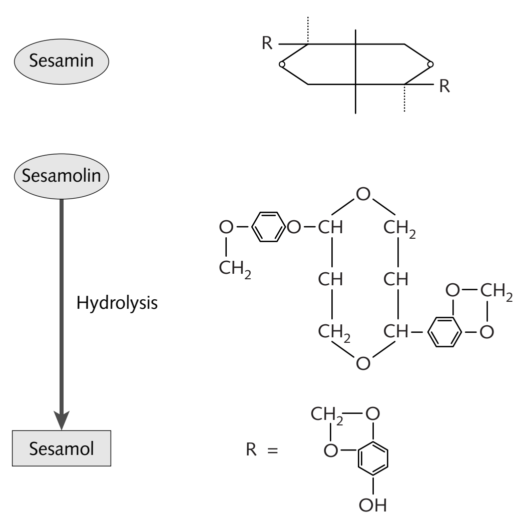

FIG. 2. Sesamin, sesamolin, and related compounds in sesame oil

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Nonglyceride components of edible oils and fats. 2. Nutritional and health significance

B. S. Narasinga Rao

Abstract

Edible oils and fats, which consist primarily of triglycerides of different fatty acids, also contain 1% to 10% of fat-soluble phytochemicals derived from oil-bearing seeds or fruits, collectively called the nonglyceride fraction. They belong to different classes of chemicals, each with a number of different chemical compounds. These chemicals are also present in the unsaponifiable fraction of oils and fats, some of them in a modified form. Several of these chemicals have been shown during the past two decades to have health-promoting functions, with vitamin, hypolipidemic, and antioxidant activities. Studies in experimental animals and humans have shown that they can have a preventive role in noncommunicable diseases, such as cancer, cardiovascular disease, and cataract. They also serve as a source of vitamin E and provitamin A. Thus, oils and fats in the nonglyceride fraction not only are sources of energy and essential fatty acids, but also have a disease-preventing and health-promoting role and can serve as a source of some fat-soluble vitamins. Certain edible oils, such as palm oil, rice bran oil, and sesame oil, are particularly rich in the health-promoting chemicals present in their nonglyceride fraction. Some of the edible unconventional oils have high levels of the nonglyceride fraction (8%–10%), and they may have important disease-preventing potential.

Introduction

Natural oils and fats contain a wide range of chemicals in their nonglyceride fraction [1]. They used to be considered as adventitious fat-soluble phytochemicals, derived from oil-bearing seeds and fruits. As pointed out earlier, many of the nonglyceride components in several of the edible oils have distinct biological functions and have nutritional and disease-preventing and health-promoting potential in humans. The available evidence indicates that these nonglyceride components compounds can have one or more of the following functions: vitamin functions; hypolipidemic activity, protecting against cardiovascular disease; and antioxidant activity, which is currently recognized as playing an important role in protecting against many diseases, such as cancer, cardiovascular disease, cataract, and metabolic disorders. Some of the oils also contain antinutritional and toxic compounds among their nonglyceride components.

Although earlier interest in nonglyceride components was purely chemical, the development of modern analytical tools has helped to separate and identify these species of chemicals in the nonglyceride fraction of oils and fats. It is only during the past two decades that much research has been carried out to establish the nutritional and disease-preventing role of bioactive nonglyceride components of edible oils. The predominant edible oils that have been subjected to in-depth investigation of these properties are palm oil and rice bran oil. The other potential candidates for such studies are sesame, wheat germ, olive, corn, and mustard oils. Several nonconventional edible oils and fats with high unsaponifiable fraction contents can be added to this list (table 1).

Nutritional and health-promoting potential of nonglyceride components of edible oils

Nutritional function: vitamin activity

The two important fat-soluble vitamins present in edible oils are vitamin E and carotenes with provitamin A activity. Vitamin E is present as tocopherols in almost all the edible oils, and their content varies considerably (table 1). Tocopherols also act as antioxidants protecting oils against auto-oxidation. There are two types of vitamin E present in edible oils, α-, β-, and γ-tocopherols and the related tocotrienols, each with different biological potencies and functions. The main

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TABLE 1. Vitamin E and polyunsaturated fatty acid (PUFA) contents of common edible oils and fats consumed in India

Edible oil	PUFA (%)	Vitamin E (T_1+T_3)(ppm)	Tocopherol T_1 (ppm)	Tocotrienol T_3 (ppm)	Vitamin E (mg/g PUFA)
Palm oil	11	1,134	642	492	10.3
Safflower oil	73	801	801	—	1.1
Cottonseed oil	51	782	782	—	1.5
Sunflower oil	49	546	546	—	1.1
Groundnut oil	28	367	367	—	1.3
Mustard oil	22	576	576	—	2.6
Corn oil	57	732	732	—	1.3
Coconut oil	2.2	36	11	25	1.6
Rice bran oil	36.6	550	181	369	1.5
Ghee	1.8	30	25–30	—	1.7

function of vitamin E in the body is to act as an antioxidant to protect the cell membrane containing polyunsaturated lipids against oxidative damage. It also has a role in reproductive function. Although tocopherols and tocotrienols are chemically related, they differ widely in their biological activity: tocotrienols are more potent in this respect than tocopherols. Although tocopherols are present in all oils, tocotrienols are present in only a few edible oils, the richest source being palm oil. Rice bran oil is also a good source of tocotrienols. The total vitamin E content (tocopherols and tocotrienols) is highest in palm oil, nearly 113.4 mg/100 g. Vitamin E content in relation to polyunsaturated fatty acid (PUFA) content is also highest in palm oil. The vitamin E/PUFA ratio is nearly 10.3 mg of vitamin E per gram of PUFA in palm oil, whereas in other oils it ranges between 1.1 and 2.6 mg/g (table 1). This ratio is a measure of the relative antioxidant potency of oils.

The other vitamin present in some edible oils is carotene, which has a provitamin A potency. Although most oils may have only traces of this pigment, red palm oil freshly extracted from the fruit is a very rich source, with nearly 600 ppm of carotenes, mostly β-carotene (table 2). Both α- and β-carotenes can serve as potential sources of provitamin A. However, refined edible-grade red palm oil contains about 500 ppm of carotenes and 400 ppm of β-carotene equivalent (table 3). Red palm oil is thus useful in promoting adequate intake of vitamin A and in preventing vitamin A deficiency among the population groups with a low intake of dietary vitamin A. This is particularly so

TABLE 2. Carotenoids in red palm oil

Carotene fraction	% distribution	Actual content (ppm)
Total	—	545.0
β-Carotene	47.4	258.0
α-Carotene	37.0	202.0
cis-α-Carotene	6.9	37.6
Photoene	2.0	10.9
Lycopene	1.5	8.2
Zea-carotene	0.5	2.7
γ-Carotene	0.6	3.3
β-Zea-carotene	0.5	2.7
cis-β-Carotene	0.8	4.4
Neurosporene	Trace	—
α-Zea-carotene	0.3	1.6
Phytofluene	1.2	6.5

TABLE 3. Red palm oil as a source of β-carotene (provitamin A) for combating vitamin A deficiency in India

Carotene content of red palm oil			Red palm oil as a source of β-carotene to meet the carotene shortage in India	
Carotenoids	Content (μg/g)	β-Carotene equivalent (μg/g)	Details	Per capita per day
α-Carotene	145	80	Recommended intake	2,290 μg
β-Carotene	310	310	Available from fruits and vegetables	1,162 μg
δ-Carotene	20	10	Shortfall	1,128 μg
Lycopene	10	0	Red palm oil intake to meet the deficit	2.82 g
Xanthophyll	15	0		
Total	500	400	Total red palm oil required per annum	0.9–1.0 million tons

in a number of developing countries, including India. A daily intake of 5 g of red palm oil can substantially meet the daily vitamin A needs of all age groups. Further, because carotene is in an oil solution in red palm oil, it may be better absorbed than carotenes from vegetable sources, such as green leafy vegetables.

In India, where vitamin A intake is low among the majority of the population and where the per capita availability of β-carotene from all fruit and vegetable sources is only 50% of the requirement, an intake of 2 to 3 g per capita per day of red palm oil can correct the vitamin A deficit, whereas 5 g of red palm oil can fully meet the daily requirement of vitamin A (table 4). An annual production of about 1.0 million tons of red palm oil could make India self-sufficient in β-carotene to meet the vitamin A needs of its population. During the past 10 years, intensive research has demonstrated the potential of red palm oil as an excellent source of β-carotene to combat vitamin A deficiency in India [2]. Crude red palm oil is regularly consumed in some of the West African countries. Consequently, vitamin A deficiency is almost absent in these countries. As far back as 1935. an attempt was made in India to demonstrate the usefulness of crude red palm oil for treating children with vitamin A deficiency and in correcting its clinical manifestation, keratomalacia [3]. In this respect, it was comparable to cod liver oil, the only other source of vitamin A then available. The Nutrition Advisory Committee of the Government of India then recommended the cultivation of oil palm in India to produce red palm oil for combating the widely prevalent vitamin A deficiency, which persists even today. It would be a practical national policy in India and in other developing countries where vitamin A deficiency is a major nutritional problem to introduce red palm oil as an edible oil to serve as a rich source of β-carotene to help eliminate vitamin A deficiency. In addition, red palm oil, a rich source of antioxidants (table 5), can serve as a functional food in protecting against other degenerative diseases.

TABLE 4. Carotene economy in India

β-Carotene source	Amount	Total available
	μg per capita per day	
Recommended intake	2,290	
Available from fruits and vegetables	1,162	
Deficit	1,128	
Contribution from red palm oil (intake in g/day)		
3	1,500	2,662
5	2,500	3,662
10	5,000	6,162

Hypolipidemic effect of nonglyceride components in protecting against cardiovascular diseases

Edible oils with high nonglyceride contents contain a number of chemical substances with a hypocholesterolemic potential (table 6). These compounds are either sterols or terpenic and alkyl alcohols. For sterols

TABLE 5. Antioxidants in nonglyceride components of vegetable oils and their health effects[a]

Antioxidant	Health effects
Tocopherols Vitamin E	Protection against cancer, diabetes, coronary heart disease, cataract, etc.
Tocotrienols	
Carotenoids–carotenes	
Phenolic compounds Sesaminol	
Isothiocyanates	
Isoprenoids	

a. Oils rich in antioxidants are palm, rice bran, olive, cottonseed, rapeseed, sesame, wheat germ, safflower, and fish oils.

TABLE 6. Hypocholesterolemic effects of nonglyceride components of vegetable oils

Nonglyceride component	Type of oil	Mechanisms of action on cholesterol
Phytosterols		
Stigmasterol	Rice bran	Decreases absorption
Sitosterol	Rape seed	Increases excretion
Campesterol	Corn	
Brassica sterol	Sesame	
Terpene alcohols		
Oryzinol	Rice bran	Decreases absorption
Cyloarterenol	Olive	Increases excretion
24-Methylene cycloarterenol	Soy, linseed	
Others		
Sesamin	Sesame	Inhibits biosynthesis
Saponin	Soy, peanut	Decreases absorption
Squalene, ferulic acid	Rice bran	

to be hypolipidemic, their content in the oil and their intake should be quite high [4, 5]. They are believed to act by competitively inhibiting cholesterol absorption from the gut [5]. The significant role of nonsterol nonglyceride components of oils in reducing blood and tissue cholesterol and other lipids has been clearly established by a series of studies on rice bran oil [6]. The unsaponifiable fraction of rice bran oil has been shown to have a hypocholesterolemic effect in both animals and humans [7, 8]. The observed effect of rice bran oil or its unsaponifiable fraction in reducing low-density lipoproteins and triglycerides in rat blood and liver is additional to that due to the PUFA content of rice bran oil [6]. Groundnut oil, which has a similar level of PUFA, does not have a similar hypolipidemic effect to that observed with rice bran oil. The hypolipidemic effect of rice bran oil is also attributed to the cyclic terpene alcohols oryzinol, cycloarterenol, and tocotrienol present in its unsaponifiable fraction [6]. The hypolipidemic effect of the terpenic alcohol cycloarterenol has been demonstrated in rats [6]. Attempts are also being made to enrich rice bran oil with oryzinol. The serum cholesterol-lowering effect of rice bran oil can be further enhanced by blending it with safflower oil in the ratio of 70:30 [9]. Although rice bran oil is the richest source of terpenic alcohol, this class of nonglyceride components is also present in corn and olive oils. This nonglyceride component fraction may contribute to the nonhypercholesterolemic effect of olive oil, which is not rich in polyunsaturated fatty acids. Although the hypolipidemic potency of olive oil is attributed mainly to its high content of monounsaturated fatty acid, it is interesting to speculate that its hypolipidemic property could also be due to its terpenic alcohol content, which may augment the effect of the monounsaturated fatty acids.

The hypolipidemic effect of rice bran oil is attributed to an increased secretion of bile, which is the main route of cholesterol excretion from the body. Thus, available information on the hypolipidemic effect of rice bran oil and its unsaponifiable fraction provides ample evidence to indicate that rice bran oil or other oils rich in cycloarterenol (oryzinol)-like components can be useful in preventing atherosclerosis and cardiovascular disease. The data suggest that rice bran oil may be one of the most healthful and safest oils for human consumption.

Several other oils, both conventional and unconventional, have high levels of unsaponifiable matter. For example, the hypocholesterolemic effect of soy sterols has been demonstrated in rats [10]. Besides the sterols and terpene alcohols present in the unsaponifiable matter of some edible oils that have been shown to be hypolipidemic, other nonglyceride components, such as the antioxidant tocopherols and tocotrienols, have also been shown to prevent cardiovascular disease (fig. 1). They do so by preventing increased blood cholesterol levels and cholesterol oxidation, which promotes lipid deposition in the arterial wall [11]. The tocotrienols in palm oil have also been shown to prevent *in vivo* cholesterol biosynthesis by inhibiting HMG-Co reductase, a crucial enzyme in cholesterol biosynthesis [12]. Tocotrienols have also been reported to have a protective effect on platelet aggregation through their modulating effect on prostanoid synthesis, that is, through reduced generation of thromboxane B_2 [13].

Another compound present in the nonglyceride components of sesame oil is sesamin, which has recently been shown to be hypocholesterolemic in rats [14]. Sesamin, as well as curcumin, has been shown to inhibit desaturation and chain elongation of essential fatty acids, especially of the *n*-6 series [14]. Sesamin was shown to have a large effect on Δ^5 desaturase and

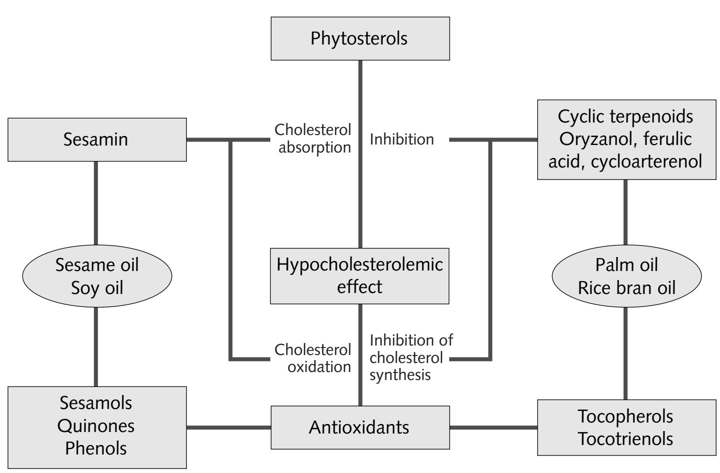

FIG. 1. Hypocholesterolemic effects of nonglyceride components of fats and oils

chain elongation of both the *n*-6 and the *n*-3 series of essential fatty acids, especially the *n*-6 series. Since long-chain polyunsaturated fatty acids are precursors of eicosanoids, sesamin and curcumin can alter the profile of those polyunsaturated fatty acids and prostanoids derived from them. Sesamin has also been shown to inhibit the synthesis of cholesterol from acetate in cultured smooth muscle cells [14]. These observations should lead to further studies in humans on the hypocholesterolemic potency of sesamin present in sesame oil.

Saponin is also present in soy and other oils. It can bind cholesterol and thus may inhibit the absorption of dietary cholesterol from the gut.

2-Phenylethanol, which is present in many vegetable oils in combination with triterpene alcohol (cycloarterenol and 24-methylene hydroarterenol), noncompetitively inhibits cholesterol esterase activity. This would result in a slow hydrolysis of cholesterol esters, thus decreasing cholesterol absorption [10].

Antioxidant potential of nonglyceride components of oils and fats

As described earlier, edible oils contain a number of antioxidants in their nonglyceride fraction (table 5). The main antioxidants present in edible oils are vitamin E, mainly the tocopherols, and in addition tocotrienols in some of the oils, such as palm and rice bran oils; carotenes in crude red palm oil; and sesaminol and sesamol in sesame oil.

There has been intensive research on the role of antioxidants in offering protection against stress-induced noncommunicable diseases, such as cancer, cardiovascular disease, diabetes, atherosclerosis, cataract, and metabolic diseases. This includes experimental, clinical, and epidemiological investigations, especially on the role of oxygen free radicals in causing cancer and cardiovascular disease and the protection offered against such diseases by antioxidants (fig. 2). Although most oils contain vitamin E, which can act as an antioxidant, wheat germ oil and palm oil are very rich in vitamin E (table 1). Palm oil and rice bran oil contain both tocopherols and tocotrienols, the latter being a more powerful antioxidant than tocopherols. Red palm oil in addition contains carotenes, which can also act as antioxidants and free radical scavengers. Thus palm oil and other oils rich in antioxidants can offer protection against cancer and cardiovascular disease. Research on the role of antioxidants (tocols and carotenes) in palm and other edible oils in protecting against cancer and cardiovascular disease was presented in a recent symposium [15]. The author has reviewed the role of antioxidants of palm oil and their health-promoting potential in the Indian context [16].

The other edible oil with powerful antioxidant activity is sesame oil, which is rich in sesamolin, an ester of the quinone-type antioxidant sesamol. Sesamol is released from sesaminol on hydrolysis. Normally, sesame oil contains only a small quantity of preformed sesamol, but it can be released in the gut during digestion. The sesamol thus released can be absorbed and act as an antioxidant in the body, offering significant protection against the diseases mentioned above. Sesamol appears to be the most potent antioxidant

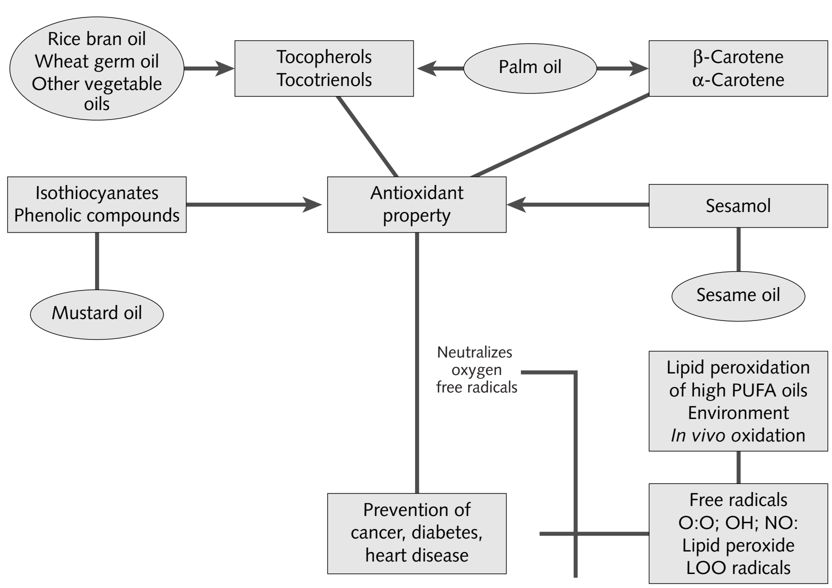

FIG. 2. Antioxidants in nonglyceride fraction of oils and fats and their health benefits

[17]. The role of sesame oil and sesamol in protecting against cancer and cardiovascular disease does not appear to have been studied in great depth, although the role of sesamol as an antioxidant to stabilize oils has been well studied [17]. This is a potential area for research in the field of nonglyceride components of fats and oils.

The other antioxidant chemicals present in edible oils, such as mustard and rapeseed oils, are isothiocyanates, allyl isothiocyanate, and oxazolidinthiones derived from glycosinolates. These compounds have anticarcinogenic activity [18] in addition to their antithyroid and goitrogenic properties.

Many of the diseases against which antioxidants offer protection, such as cancer, cataract, atherosclerosis, ischemia, and pulmonary dysfunction, are believed to be caused by oxygen free radicals, such as singlet molecular species of oxygen, superoxide, hydroxyl, peroxide, and lipid peroxide radicals [19]. Lipid peroxidation of membrane lipids and of circulating lipoprotein lipids, including cholesterol, and oxidative damage of proteins (e.g., lens protein) and DNA, are believed to be mechanisms by which oxygen free radicals and peroxide radicals contribute to the development of these diseases (fig. 2).

Such oxygen free radicals are constantly generated in the cells during oxygen utilization and can also be derived from environmental pollution. Although there are protective mechanisms such as superoxide desmutase to destroy these free radicals generated *in situ*, they may not be adequate. It is in such a situation that dietary antioxidants can augment the mechanism *in vivo* by destroying the free radicals, thus protecting against diseases caused by them (fig. 2).

Future research possibilities and needs in the area of nonglyceride components of oils and fats

In the light of the foregoing discussion, the following areas of research can be suggested to exploit the disease-preventing and health-promoting potential of nonglyceride components of oils and fats.

More detailed analysis of chemicals present in the nonglyceride components or unsaponifiable fractions of hitherto unexplored oils and fats, especially the unconventional oils, which have high levels of unsaponifiable fractions and which have been shown to be safe for human consumption.

More detailed studies, in both animals and humans, of sesame oil, the nonglyceride fraction of which is rich in sesamin, sesamolin, and sesamol, to establish the hypocholesterolemic (sesamin) and antioxidative (sesamol) potential of these compounds against cancer, cardiovascular disease, etc.

Clinical and epidemiological studies with rice bran oil, red palm oil, and sesame oil to test their efficacy in protecting against noncommunicable diseases such as cancer and cardiovascular disease. Based on such studies, a prophylactic dosage of these oils in the functional foods based on these oils can be determined.

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Discussion paper brief. Food Consumption and Nutrition Division of the International Food Policy Research Institute (IFPRI)

Discussion paper 92. Assessing the potential for food-based strategies to reduce vitamin A and iron deficiencies: A review of recent evidence

Marie T. Ruel and Carol E. Levin

Balanced diets are not accessible to a large proportion of the world's population, particularly those who live in developing countries. Many populations subsist on staple plant-based diets that often lack diversity (and sometimes also quantities), which may result in micronutrient deficiencies. Vitamin A and iron deficiencies are among the nutritional deficiencies of greatest public health significance in the world today. Because they disproportionately affect children and women during their reproductive years, they hinder both the development of individual human potential and national social and economic development.

The most popular approaches to address vitamin A and iron deficiencies include the distribution of vitamin supplements, food fortification, nutrition education, and food-based strategies. Also referred to as dietary modification, food-based approaches use a combination of agricultural, educational, and nutritional strategies to increase the production of, availability of, access to, and consumption of micronutrient-rich foods.

Food-based approaches neglected

In recent years, food-based interventions have been largely driven by nongovernmental organizations and other local institutions and have often been overshadowed by national campaigns to reduce micronutrient malnutrition through capsule-distribution and food-fortification programs. Perceived to be less cost-effective and certainly requiring a longer time horizon to achieve results as compared with supplementation or fortification interventions, food-based interventions have been neglected by national strategies to combat micronutrient deficiencies. And yet, these strategies may provide the only sustainable approach at the community level to improve the intake of iron and vitamin A through culturally acceptable changes in dietary intakes. This review explores recent evidence for the impact and effectiveness of food-based strategies, in an effort to reexamine the potential of food-based strategies to reduce micronutrient malnutrition.

Objective of the review

The objective of the review was to synthesize current knowledge of and experience with food-based approaches to reduce vitamin A and iron deficiencies, to highlight some of the lessons learned, and to identify knowledge gaps and research priorities. The main strategies reviewed are food-based interventions that aim at increasing the production of, availability of, and access to foods rich in vitamin A and iron through the promotion of home production; increasing the intake of these foods through nutrition-education, communication, social-marketing, and behavior-change programs; and increasing the bioavailability of vitamin A and iron in the diet through home preservation or processing techniques. Plant-breeding strategies are also briefly discussed because of their potential to increase the content of vitamin A and iron in the diet.

Strategies to increase production and/or intake of micronutrient-rich foods

Building on two previous reviews of home gardens from the 1980s and early 1990s, this review covers evidence from 10 new projects published between 1995 and 1999. Compared with previous studies, the new set of studies focuses more on community participation aspects and on the careful selection of appropriate sets of interventions for specific contexts. Design and implementation strategies have also greatly improved. Consistently with findings from earlier reviews, this synthesis highlights the effectiveness of home-gardening interventions, especially when combined with promotional and educational interventions, to improve vitamin A intake and nutrition. The review also suggests a positive impact of interventions to promote small-animal husbandry and fishponds, or increased intake of cheap sources of animal products for the control of iron deficiency. A key element of success in this new generation of food-based interventions seems to be the emphasis on well-designed communication and behavior-change strategies. In spite of these encouraging findings, there is still an urgent need for better and more rigorous evaluations of food-based interventions to demonstrate their efficacy, effectiveness, feasibility, sustainability, cost-effectiveness, impact on micronutrient status, and outcomes such as home production, household income, and women's control over resources.

Strategies to increase bioavailability of vitamin A and iron

Various home-processing techniques can be used to either increase the bioavailability of micronutrients or ensure their retention during preparation, cooking, processing, and preservation. For provitamin A compounds, the main issue is to extend the availability of provitamin A-rich foods beyond the season in which they are in abundance. This can be achieved through solar drying or the production of leaf concentrates. For iron from plant foods (nonheme iron), the most crucial issue is to increase bioavailability by either reducing the presence of inhibitors of absorption (such as phytic acid or tannins), or increasing the use of promoters (such as ascorbic acid). Home-processing techniques, such as germination, fermentation, and amylase treatment, are known to be effective in reducing the amount of phytic acid in cereals and legumes and in promoting the absorption of nonheme iron. Avoiding tea and coffee during the meal and including citrus fruits, which are rich in ascorbic acid, are other effective approaches to improve nonheme iron absorption. A few recent studies also showed that cooking in iron pots increased the intake of bioavailable iron in the foods and improved iron status.

Our review of these strategies reveals two contrasting facts. On the one hand, it is clear that the technologies exist to address some of the main concerns about the bioavailability of vitamin A and iron. Many of the technologies reviewed seem to involve simple, low-cost home-processing techniques, which in some cases are even part of the traditional background of the targeted populations. On the other hand, the lack of experience in promoting, implementing, and evaluating these available technologies in community trials is disconcerting. More research is needed to explore the full potential of these approaches for the control of vitamin A and iron deficiencies.

Plant-breeding strategies

Plant-breeding strategies are promising because of their immense potential to improve the dietary quality of populations relying mainly on cereal staples. However, they are at a very early stage compared with other approaches, and information on their potential efficacy and effectiveness is not yet available. Additional studies on human bioavailability are needed to understand the potential contribution of plant-breeding to the global strategy to alleviate micronutrient deficiencies.

Conclusions

Significant progress has been achieved in the past 10 years in the design and implementation of food-based approaches, particularly with respect to the new generation of projects integrating production with nutrition-education and behavior-change strategies. Yet, little has been done to rigorously evaluate their efficacy, effectiveness, feasibility, cost-effectiveness, sustainability, and impact on the diets and nutritional status of at-risk populations. Food-based approaches are complex, requiring a set of integrated activities and a wide variety of inputs and outcomes to be measured. Their impact is more difficult to evaluate than that of other strategies, such as capsule-distribution programs, because they cannot be evaluated by randomized, placebo-controlled trials. However, it is critical to demonstrate both the efficacy and the effectiveness of food-based strategies in order to provide the most basic information to further promote their use in the fight against micronutrient malnutrition. The same question as that posed in previous reviews decades ago remains at the end of the present review: What really can be achieved with food-based interventions to control vitamin A and iron deficiencies? Food-based approaches could be an essential part of the long-term global strategy to alleviate vitamin A and iron deficiencies, but their real potential is still to be explored.

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Discussion paper brief. Food Consumption and Nutrition Division of the International Food Policy Research Institute (IFPRI)

Discussion paper 94. Targeting urban malnutrition: A multicity analysis of the spatial distribution of childhood nutritional status

Saul Sutkover Morris

In many developing countries, the number of malnourished children in urban areas is increasing. To stem the growth of urban malnutrition, effective interventions are needed that reach those at greatest risk. Current strategies to reach these individuals appear to have been strongly influenced by the prevalent view that, in UNICEF's words, "urban poverty is primarily concentrated in squatter settlements and slum areas." This statement implies that urban neighborhoods are highly differentiated with respect to manifestations of social deprivation, but that within neighborhoods, conditions are largely homogeneous.

Empirical data for this claim, however, are surprisingly limited. For example, the author's forthcoming examination of survey data found that in Abidjan, Côte d'Ivoire, garbage collection and access to potable water were indeed unequally distributed across neighborhoods, but that nutritional status showed no "clustering" in particular areas. In Accra, Ghana, nutritional status was also heterogeneous within neighborhoods, as were many other variables, such as household income, source of drinking water, and education of the head of the household. If nutritional status is not clustered by neighborhood, then nutritional interventions that are geographically defined will lead to serious undercoverage of those at risk, as well as to provision of program benefits to the non-needy.

Purpose and methodology of this study

This paper attempts to determine the degree to which malnutrition, poverty, overcrowding, substandard housing, lack of potable water, child mortality, and infectious diseases are clustered by neighborhood in seven different cities in Africa, Asia, and Latin America. The analysis is based on data from eight different national household surveys using a two-stage sampling design (households within clusters). Spatial clustering was assessed using the intracluster correlation coefficient (p), which may be interpreted as the proportion of the total variance in a variable that is associated with the cluster to which it belongs.

Results

In general, per capita expenditures and the share of the household budget spent on food showed a high level of spatial clustering across the seven cities, but the magnitude of this clustering varied markedly from city to city. Spatial clustering in the provision of basic services also varied greatly. There was consistently little evidence of spatial clustering of infectious disease, childhood mortality, or the weight-based nutrition indicators. Age-standardized height, on the other hand, showed slightly more spatial clustering, with a median intracluster correlation of $p = .12$. Some cities showed relatively higher levels of spatial clustering on several measures of deprivation simultaneously, while other cities showed consistently lower levels of clustering.

Discussion and conclusions

The study suggests that the conventional view of urban deprivation greatly oversimplifies the reality. The complex patterns revealed in this study have important policy implications.

First, it is necessary to consider whether the levels of spatial clustering of childhood nutritional status identified are sufficiently high to justify the geographic targeting of nutritional interventions in cities. Physical upgrading programs are intrinsically geographically targeted, yet the large outlays involved are frequently justified by invoking the supposed health benefits that will result.

Local economic development initiatives may also have less effect on childhood nutritional status than might be imagined if large numbers of vulnerable households are not located in the target areas. With respect to community-based initiatives, some of these are necessarily geographically targeted—the *comedores populares* or soup kitchens of Lima are an obvious example—while others, such as food and nutrition education or micronutrient supplementation, are not. However, even when the type of intervention permits alternative approaches, geographic targeting tends to be administratively simpler than individual targeting. In addition, political considerations may favor highly visible interventions in obvious "problem" communities, rather than more subtle approaches to identifying those in greatest need.

The current analysis suggests that where nutritional interventions are focused on stunting (low height-for-age), there may be some limited scope for targeting by neighborhood in cities with high structural inequalities, such as in South Africa and Latin America. However, even in these cases, it should be borne in mind that neighborhoods are far from homogeneous, and that both undercoverage and leakage of program benefits will result from restricting benefits to a few neighborhoods. On the other hand, only in very particular cases—such as in Bangladesh—are urban nutrition programs likely to be focused on wasting (low weight-for-height), since this problem is not prevalent in most urban areas.

The low levels of spatial clustering of nutritional status observed thus pose a problem for the design of effective nutritional interventions. The very same problems of undercoverage and provision of benefits to the non-needy that led to disillusionment with citywide approaches are present again as arguments against excessively localized interventions in the area of nutrition. However, the implementation of nutrition programs at the citywide level is likely to be fraught with difficulties, because the resources required for endogenous development—such as effective community activist groups—are to be found at the local, not the city, level.

Furthermore, even if geographic targeting of nutritional interventions is inadequate, it remains to be determined what alternative model might replace the "pockets of undernutrition" framework in guiding the design of effective programs for the cities of tomorrow.

The full texts of this document and other FCND discussion papers are available at the IFPRI website: www.cgiar.org/ifpri/divs/fcnd/dp.htm*, or via* B.McClafferty@cgiar.org

Erratum

The affiliations of the authors for the article "Evaluation of nutrition education for improving iron status in combination with daily iron supplementation" [Food Nutr Bull 2000;21(3):259-60] were inadvertently omitted from the article. The affiliations are as follows:

Pulani Lanerolle is a Research Officer and Sunethra Atukorala is a Professor affiliated with the Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo in Colombo, Sri Lanka. Geethanjali de Silva, Swarnamali Samarasinghe, and Lakshmi Dharmawardena are Medical Officers affiliated with the Office of the School Medical Officer in Colombo, Sri Lanka.

Letters to the Editor

Dear Sir,

Cooking oil: an effective vehicle for vitamin A or carotene supply to the population

The excellent meeting on vitamin A deficiency held in 1999 before the Asian Congress of Nutrition and published in the *Food and Nutrition Bulletin* (Volume 21, Number 2, June 2000) is a reference for everyone interested in and working on vitamin A and carotene. It included an overall review of this world nutritional problem and called attention to the importance of dietary approaches and specifically of red palm oil in the prevention of vitamin A deficiency. Sugar has been fortified with vitamin A in many of the Central American, and several other, countries, but other alternatives should also be tried to guarantee vitamin A intake. In Brazil several studies reported a low intake of vitamin A and its precursors in several parts of the country, including low serum vitamin A levels in children. Few severe cases of deficiency with eye lesions were reported, but vitamin A deficiency plays a role in growth, infection, and other aspects of nutritional health. Experimental fortification of milk, rice, wheat flour, sugar, and cooking oil has been carried out in the country. So has administration of massive doses of synthetic vitamin A during immunization campaigns, but this has not continued. Considering the prevalence of world vitamin A deficiency, it is disturbing that little attention has been paid to the use of cooking oil as an effective vehicle to deliver vitamin A or carotene to the populations in need.

Red palm oil, used in the local preparation of traditional dishes of African descendant groups, and *buriti*, another palm oil vitamin A source, are available and have been shown to supply vitamin A to groups with vitamin A deficiency [1]. Their widespread use is a long-range possibility. At the 1999 meeting on vitamin A deficiency, only two papers on the subject were presented. In one study from India [2], red palm oil was incorporated into edible oils at concentrations of 6% to 12% to provide carotene to the local daily diet. It was pointed out that carotene was retained even after potato chips had been fried in this oil, and it was suggested that this blend be produced commercially. In the Philippines [3], a cooking-oil manufacturer developed and tested a vitamin A–fortified cooking oil. It was stressed that the vitamin A was soluble in the oil, stable, and did not change its color, flavor, or acceptability. Vitamin A was retained even in fried bananas, sweet potatoes, rice, and fish.

For the past 10 years, we have studied and reported on different aspects of the fortification of cooking oil with vitamin A and carotene. Brazil is one of the largest producers of vegetable oil, mainly soy. It is used extensively in daily food preparation and consumed all over the country. In 1991 [4] we fortified soybean oil with all-trans-retinyl palmitate and tested its stability during storage and when used for boiling or frying. It was 100% stable after six months in both sealed and open cans stored at room temperature. When it was used for the usual cooking of rice and beans, vitamin A retention ranged from 88% to 99% as compared with the values for unheated oil. When potato chips were fried in fortified oil, a 48% loss of vitamin A was found only after four frying sessions, so that it was still a useful source of vitamin A. The biological values of these vitamin A–fortified oils heated to 100° or 170° C were tested in standard rat assays that confirmed that both unheated oil and oil heated to 100°C sustained normal plasma and liver vitamin A values. They decreased only at higher temperatures [5]. In 1994 [6] we reported that vitamin A was well absorbed by humans, as determined by plasma levels, from food prepared with vitamin A–fortified soybean oil.

A series of similar studies was carried out with synthetic carotene added to soybean oil. Liver vitamin A levels increased in rats fed diets containing unheated, carotene-fortified soybean oil. Heating the oil to 100°C caused a 10% decrease and heating it to 170°C caused a 26% decrease in liver vitamin A values, compared with the values in unheated oil [7]. Absorption of carotene from rice prepared with soybean oil fortified with provitamin A was measured in healthy adults. Plasma carotene values rose from the fasting value when the oil was cooked with rice or poured on the cooked rice [8]. The possibility of blending products of soybean oil with palm oils in Brazil, such as red palm oil, was studied as an alternative source of vitamin A for our population. Supplementation of diets with the same amount of synthetic carotene or red palm oil carotene resulted in similar levels of vitamin A in rat liver and plasma (unpublished experiments).

Since a small group of large companies produce most of the vegetable oil used in Brazil, fortification of cooking oil with fat-soluble vitamins would have no technological problems, would be low cost, and would have no palatability problems. This approach certainly has a great potential for wide use by the Brazilian population and those in other similar countries. Unfortunately its large-scale implementation is not receiving the support from expert groups and international organizations that is provided for supplementation with synthetic vitamin A.

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Dear Sir,

Natural food sources of provitamin A that have previously been unrecognized

Much has been written about the importance of promoting natural food sources of vitamin A [1–3] and the range of interventions for addressing the problem of vitamin A deficiency [4], including targeted supplementation programs and sustainable, consumer-funded interventions to improve the diet and to address the whole population at risk. Recently several natural foods from Micronesia of which the composition was previously unknown were found to be good sources of provitamin A carotenoids.

The Federated States of Micronesia (FSM), where I was working from late 1997 to early 2000 in a UNICEF-supported project, is made up of four states: Pohnpei, Chuuk, Kosrae, and Yap. Vitamin A deficiency is a problem of major public health significance in all four states [5-8]. There have been great changes in dietary intake and lifestyles in recent years. Imported foods, including rice, sweet foods, and refined foods, have become the basis of the diet of many people, replacing the local island food. This appears to be associated with adverse health consequences, particularly poorer vitamin A status.

Because of this problem, efforts were made to identify local foods rich in provitamin A carotenoids that could be promoted to improve vitamin A nutritional status. Informal focus-group discussions and interviews identified a special type of banana called *karat* (*Musa troglodytarum)*, with orange-colored flesh, that was known as a traditional weaning food in Pohnpei. Other foods were also identified as potential sources of provitamin A. Specimens of ripe *karat*, plus a variety of yellow banana and one of the local staple foods, the yellow swamp taro of Yap, were obtained. Samples of the ripe raw bananas and the cooked taro were sent for analysis by high-performance liquid chromatography (HPLC) and were found to be high in provitamin A carotenoids.

The *karat* banana was sent to two laboratories for HPLC analysis. It was found to contain 111 retinol equivalents (RE)/100 g in one laboratory and 160 RE/100 g in the other laboratory [9]. These amounts of provitamin A are comparable to those in papaya and mango. The *karat* banana is quite unusual in that it fruits by the bunch, growing straight up into the air. Its ripe fruit is roundish in shape with a reddish skin and orange flesh. *Karat* also grows in Kosrae and Yap, but appears to have died out in Chuuk State. Because of neglect, the banana is now rare in all states. It is a bit harder to grow, because it requires very fertile soil and is sensitive to strong sunlight. However, unlike other banana varieties, it is resistant to leaf-streak disease. There is now a great demand for *karat*, but the planting material is insufficient to meet demand.

The second banana, the *mangat* (*Musa* spp) of Pohnpei, was found to be a rich source of carotene as well, with 96 RE/100 g [Shovic A, Covance Laboratories, Madison, Wisc, USA, personal communication, 2000]. The finding may be compared to the results on two further Pohnpei bananas, *uht en ruk* and *inasio*, that were analyzed at the same time in the same laboratory and found to contain 12 and 20 RE/100 g, respectively. Both *karat* and *mangat* are eaten raw when ripe and are also eaten cooked.

Finally, a cooked sample of the yellow swamp taro of Yap known as *lak* (*Cyrtosperma chamissonis*) was found to contain 152 RE/100 g. Because *lak* is a staple food, it has the potential to provide meaningful quantities of provitamin A to the Yap diet. These findings compare favorably with the Food and Agriculture Organization/World Health Organization (FAO/WHO) recommended daily intake for vitamin A of 400 RE for children one to six years old [9].

Efforts are being made by FSM national and state health and education services and community groups to increase the production and consumption of these traditional foods. Competitions in schools, cooking demonstrations, leaflets, and media messages have been part of this campaign, as reported in the *Sight and Life Newsletter* in 1999 [10]. Efforts have also been initiated to reintroduce the *karat* banana into Chuuk State. The activities are a part of the FSM vitamin A program, which also includes biannual high-dose vitamin A supplementation for children 1 to 12 years of age and for mothers immediately after delivery.

These findings are the first report of provitamin A–rich bananas and taro [11–13]. The retinol activity of all three should be confirmed in other samples, and efforts should be made to analyze additional foods identified for their potential provitamin A content. There may be a number of traditional foods with significant provitamin A content that are still unrecognized and that are in danger of being lost to the modern westernized diet. These foods may be a good focus for promotion to help prevent vitamin A deficiency.

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Editorial note: *This letter was submitted while the June 2000 special issue of the* Food and Nutrition Bulletin, *devoted entirely to dietary approaches to the prevention of vitamin A deficiency, was in press. It is a useful contribution to the* Bulletin's *efforts to disseminate information supporting food-based approaches to the prevention of nutritional deficiencies.*

Books received

Antioxidants in human health and disease. Tappan K. Basu, Norman J. Temple, and Manohar L. Garg. CABI Publishing, New York, 1999 (ISBN 0-85199-334-6). 450 pages, hardcover. US$60.00.

The last decade has seen an explosion in evidence for a role of antioxidants in human health, with conflicting evidence, controversy, and growing conviction of its importance. This book has 31 chapters by experts covering the full range of current discussion of the role of antioxidants in health and disease. They include the mechanism of action of antioxidants, specific antioxidants in foods, and evidence for their role in coronary heart disease and cancers. The possible and still speculative role of antioxidants in a variety of other diseases is well covered, with emphasis on the kind of research required. These include diabetes, cataracts, macular degeneration, respiratory diseases, cystic fibrosis, cognitive decline in the elderly, schizophrenia, and Alzheimer's disease. The findings in this rapidly evolving area of medicine are of interest not only to nutritionists, researchers, and students but also to practicing physicians and health professionals.

Cross-national and cross-cultural issues in food marketing. Edited by Erdener Kaynak. Haworth Press, Binghamton, NY, USA, 1999 (ISBN 0-7890-0981-1). 101 pages, paperback. US$19.95; outside US, $24.00.

This small book evaluates the present state and likely developments of food-marketing systems in different countries and cultures. After a review of the issues by the editor, four chapters by different authors examine specific marketing issues in the United States, Pakistan, Spain, and the European Union. This is not a useful book for the general reader, but professionals with specific interest in the topic will find the case studies of interest.

Developmental pathways of the malnourished child: Results of a supplementation trial in Indonesia. Edited by Ernesto Pollitt and Beat Schürch. Supplement 2, European Journal of Clinical Nutrition 2000; 54:S1–S110.

This journal supplement consists of 14 individually authored articles based on various aspects of a study in Indonesia. It tested the proposition that energy and micronutrient supplementation during early life prevents, at least in part, the growth retardation and developmental delays generally observed among undernourished children in low-income populations of developing countries. The premise of the study was that supplementation effects are not independent, but interact, and that in combination they reorient the psychobiological differentiation of children towards a normal developmental path. There is no overall summary of the findings, but the papers support the concept that the earlier the onset and the longer the duration of undernutrition, the greater the probability of impaired physical and intellectual development. The papers reporting on the positive results of nutritional supplementation provide strong evidence that this impairment can to a significant degree be prevented by this measure. The publication provides further support for programs to prevent undernutrition and infections at an early age in developing countries, as promoted by the World Bank publication *Early Childhood Counts*, which is reviewed below.

Early childhood counts: A programming guide on early childhood care for development. Judith L. Evans with Robert G. Myers and Ellen M. Ilfeld. World Bank, Washington, DC, 2000 (ISBN 0-8213-4567-2). 412 pages, paperback. US$30.00. Also available in CD-ROM (ISBN 0-8213-4568-0) for US$30.00. Both print and CD-ROM available for US$50.00.

The future of nations depends on the quality of early childhood development. Where malnutrition and disease physically impair early physical and mental development and these effects are compounded by a lack of stimulation, the capacities of each generation to learn and work are impaired. Yet, with globalization, “human capital” is an increasingly important proportion of all economies. The World Bank has made an important contribution by commissioning and publishing this comprehensive guide to the advocacy, development, and implementation of programs to improve child care in all countries.

The volume presents the important findings of social scientists, educators, and an array of biomedical disciplines. Nutrition is an important component of early child care and is well covered. The difficulties and limitations of specific programming approaches, as well as the important positive effects of good early child care, are emphasized. The value of this publication is greatly enhanced by an available CD-ROM that includes the book in electronic form plus two media sections with videos, slide shows, and fact sheets, as well as a library of more than three thousand background texts and program examples in a searchable database. It is hoped that the World Bank will find ways to distribute this guide to governmental and nongovernmental agencies in developing countries that may find its cost a barrier. Agencies concerned with early child growth and psychosocial development in all countries will greatly benefit from this publication. It will also be valuable for day-care centers, parents, and policy makers at all levels.

Feeding the world: A challenge for the twenty-first century. Vaclav Smil. MIT Press, Cambridge, Mass, USA, 2000 (ISBN 0-262-19432-5). 360 pages, hardcover. US$32.95.

This book by a professor of geography at the University of Manitoba takes a complete food-cycle approach. It is concerned not only with food production, postharvest food losses, and food-processing, but also with consumer food needs and food waste. It arrives at the optimistic conclusion that there are no insurmountable obstacles to feeding humanity in the decades to come, at the same time reducing the burden of modern agriculture on the biosphere. The book covers such fundamental issues as photosynthesis and crop productivity; land, water, and nutrients; ecosystems and biodiversity; environmental change and agroecosystems; better use of fertilizer and water and aquaculture; higher cropping efficiencies; and more rational animal food production. A final chapter considers whether the country with the largest population in the world can continue to feed itself. It concludes that although there are no insurmountable biophysical reasons why China should not continue to feed itself for the next two generations without further weakening of the country’s environmental foundations, there is no certainty that it will do so. The author suggests that this conclusion can also be applied to the entire world. The book is well researched and clearly calls on the work of hundreds of experts in the different fields, with a dozen from the Food and Agriculture Organization, the International Food Policy Research Institute, and other organizations specifically acknowledged. This book will be most useful in stimulating and guiding national food policies.

Natural food antimicrobial systems. Edited by A. S. Naidu. CRC Press, Boca Raton, Fla, USA, 2000 (ISBN 0-8493-2047-X). 818 pages, hardcover. US$149.95, £93.00.

Many traditional food-preservation practices utilize the functionality of naturally occurring antimicrobial compounds. Taking advantage of the numerous antimicrobial compounds in foods can reduce reliance on synthetic preservatives. This volume provides a comprehensive review of natural antimicrobial systems in foods, which include a number of lacto-antimicrobials, ovo-antimicrobials, phyto-antimicrobials, and bacto-antimicrobials. “Milieu-antimicrobials” that are used as antimicrobials include sodium chloride, polyphosphates, and chlorocides, and the 29 chapters by a variety of experts discuss the individual substances in each of the categories. Only a few of these have been tested on or applied to foods. It is important that research on this potentially important topic be expanded in both developing and industrialized countries. This book can be a valuable background and stimulus for this.

Nutrition and exercise immunology. Edited by David C. Nieman and Bente Klarlund Pedersen. CRC Press, Boca Raton, Fla, USA, 2000 (ISBN 0-8493-0741-4). 191 pages, hardcover. US$89.95, £56.00.

Over the past few decades, the relationship between nutritional status and immunity has been increasingly documented. We are now in an era in which the mechanisms of interaction between individual nutrient deficiencies and specific immune functions are being increasingly revealed. Almost any significant nutritional deficiency has multiple adverse effects on immunity. Since the immune system can respond in only a limited number of ways, it is not surprising that the same effects are recorded for most nutrient deficits. Metabolic changes associated with strenuous physical exercise also affect some of these immune functions. In this volume, leading investigators from around the world review the link between nutrition and immune function, with special application to athletic endeavor.

Out of the shadow of famine: Evolving food markets and food policy in Bangladesh. Raisuddin Ahmed, Steven Haggblade, and Tawfiq-e-Elahi Chowdhury. Johns Hopkins University Press, Baltimore, Md, USA, 2000 (ISBN 0-8018-6476-3). 307 pages, paperback.

Bangladesh has suffered from repeated famines in the past century, although in recent years it has made important gains in food production. Although massive poverty and food insecurity persist, the threat of famine has been greatly reduced. Following rapid structural change in Bangladesh's food grain production, liberalization in key agricultural input markets, and sustained investment in rural infrastructure, food grain production more than doubled from 1961 to 1992. In achieving this, Bangladesh managed to downsize large-scale food-distribution programs and reduce heavy food subsidy costs against all odds. This valuable study reviews what other countries can learn from the success of Bangladesh in executing and maintaining its food policy reforms.

Reduction of maternal mortality: A joint WHO/UNFPA/UNICEF/World Bank statement. World Health Organization, Geneva, 2000 (ISBN 92-4-156-195-5). 40 pages, paperback. Sw Fr 14.00, US$12.60. Sw Fr 9.80 in developing countries. Available in English, French, and Spanish

This slender volume draws together the facts, arguments, and lines of action needed to reduce maternal mortality from current levels of nearly 600,000 annually in a statement incorporating the shared views of the sponsoring United Nations agencies. It represents their common commitment to complementary programs destined to reduce and prevent maternal and neonatal mortality and morbidity. It also presents a welcome commitment on the part of key UN agencies. After describing a series of international actions, it comes to the final conclusions that both historical and contemporary evidence shows that reducing maternal mortality can bring about essential changes. They include a societal commitment to ensuring safe pregnancy and birth by decision makers at all levels, improvements in access to and quality of health care, and a commitment to the special needs of girls and women throughout their lives. This will be a very helpful booklet for those concerned with policy and program advocacy at the national level.

The return of ω3 fatty acids into the food supply: Land-based animal food products and their health effects. Edited by Artemis P. Simopolous. Karger, Basel, 1998 (ISBN 3-8055-6694-8). 240 pages, hardcover. Sw Fr 247.00, DM 296.00, US$215.00.

The change in fat composition with modern animal-feeding practices is believed to be a major contributor to the increase in atherosclerosis and coronary heart disease in the twentieth century. Grazing animals in the wild have less total fat, less saturated fat, and more polyunsaturated fat, with a ratio of ω6 to ω3 fatty acids of less than 2/1. Similar changes occurred in the composition of eggs, poultry, and fish from aquaculture as the animals became artificially fed. Thus the animal protein of the twentieth century was very different in composition from that to which humans were adapted when their genetic composition was established at least 40,000 years ago.

A key to lowering the risk is thought to be a decrease in saturated fat relative to unsaturated fat, and particularly ω3 fatty acids. This book, based on a 1997 international conference, has 32 chapters that cover ω3 fatty acids and health, ω3 fatty acids in land-based animal-food products, and the utilization of ω3 fatty acids in ruminants. Current consumption of total fat, saturated fat, ω6 fatty acids, and *trans*-fatty acids is not consistent with good health and is particularly inappropriate for persons genetically predisposed to chronic disease. Nine of the chapters indicate ways in which altered feeding practices can increase the ω3 fatty acids in foods of animal origin. This unique book well covers a relatively neglected but important aspect of human nutrition.

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International Dietary Energy Consultative Group (IDECG). Secretariat: Nestlé Foundation, 4 Place de la Gare, Lausanne, Switzerland. Executive Secretary: Dr. Beat Schürch. Tel. 4121 320 3351. Fax: 4121 320 3392. Executive committee: Dr. Nevin S. Scrimshaw, Chairman; Dr. Joseph Hautvast, Dr. Beat Schürch

Amino acid requirements

Massachusetts Institute of Technology, Cambridge, MA 02139, USA. Principal investigator: Dr. Vernon R. Young
Nutrition Research Centre, St. John's Medical College, Bangalore 560 034, India. Principal investigator: Dr. Anura Kurpad

Iron-deficiency anemia

Group for the Control of Iron Deficiency (GCID). Secretariat: Department of Nutrition Sciences, 119 Morgan Hall, University of California, Berkeley, CA 94270, USA. Tel. (510) 642-6900. Executive Secretary: Dr. Fernando Viteri. Chairman: Dr. Nevin S. Scrimshaw
Beijing Medical College—UNICEF, Department of Nutrition and Food Hygiene, Beijing, China. Principal investigator: Dr. Shiu-yun Liu
Ecole Nationale de Médecine et de Pharmacie du Mali, Service Hématologie, Bamako, Mali. Principal investigator: Dr. Dapa Diallo
Food and Nutrition Research Institute, Manila, Philippines. Principal investigator: Dr. Rodolfo Florentino
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Institute of Nutrition of Central America and Panama (INCAP), Carretera Roosevelt, Zona 11, Guatemala City, Guatemala. Principal investigator: Dr. Benjamín Torún
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Nutrition Research and Development Centre, Komplek GIZI, Jalan Semboja, Bogor, Indonesia. Principal investigator: Dr. Mahdin Husaini
Tanzania Food and Nutrition Centre, Dar es Salaam, Tanzania. Principal investigator: Dr. F.P. Kavishe
Venezuelan Institute of Scientific Research (IVIC), Apartado 1827, Caracas, Venezuela. Principal investigator: Dr. Miguel Layrisse

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

Book or other monograph reference

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

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