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Quantifiable impact on poverty in Trinidad and Tobago of the Uruguay Round Agreement on Agriculture

Carlisle Pemberton and Deokie Ramnarine

Abstract

Background. *The agreement on agriculture and the World Trade Organization were major outcomes of the 1986–1994 Uruguay Round (UR) negotiations within the General Agreement on Tariffs and Trade (GATT). The measures under the UR were predicted to increase poverty in developing countries, a serious cause for concern since poverty alleviation is a major goal of developing countries. Thus this paper simulated the impact on poverty of the UR for a net food importing country, Trinidad and Tobago.*

Objective. *The objectives of the study were to determine the changes in poverty levels in Trinidad and Tobago that we expected would result from changes in the price levels of food commodities after the removal of trade protection following the UR, and to examine recent trends in poverty in Trinidad and Tobago and the prices of major agricultural exports from the United States, its principal trading partner.*

Methods. *A regression model (poverty model) was used to determine the relationship between poverty levels and the prices of sensitive imported food commodities (SIFCs) and other key economic variables. Impact models were used to project changes in world market prices of the SIFCs due to the UR, and these price changes were used to predict changes in poverty in Trinidad and Tobago.*

Results. *The results showed a positive elasticity between poverty and the prices of SIFCs. The study also predicted that the average projected increase in price levels of the SIFCs of less than 9% by the year 2000 would cause an increase in poverty in Trinidad and Tobago of less than 4%.*

Conclusions. *There has been, in fact, a small decline in poverty in Trinidad and Tobago since 1996. The prices of major agricultural exports from the United States have also been falling since 1995. Thus, so far the UR has had no perceptible effects in increasing the prices of food exports from the United States. Also, so far the UR has had no perceptible effect on the poverty level in Trinidad and Tobago.*

Key words: General Agreement on Tariffs and Trade (GATT), poverty, poverty models, Trinidad and Tobago, Uruguay Round

Background

Agricultural trade reforms under the Agreement on Agriculture as well as the establishment of the World Trade Organization (WTO) were major outcomes of the 1986–1994 negotiations, called the Uruguay Round, within the General Agreement on Tariffs and Trade (GATT). The measures under the UR were expected to reduce agricultural protection and market distortions and improve access to agricultural markets worldwide. Countries such as the United States and members of the European Union, which have high levels of agricultural subsidies and other forms of domestic market protection, were expected to reduce these forms of domestic market protection, thus causing increases in the prices of their agricultural exports. These reforms, therefore, were expected to lead to increases in world prices of agricultural goods after 1995 [1].

Trinidad and Tobago is an exporter of petroleum and related products. The agricultural sector in 2004 contributed just 0.76% of the real gross domestic product (GDP), whereas the petroleum industries contributed 40.9% [2]. Although Trinidad and Tobago exports sugar, cocoa, and other agricultural commodities, the country is largely and increasingly a net importer of food (**table 1**). The category “food and live animals” now constitutes approximately 2% of total exports and

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TABLE 1. Exports and imports of food and live animals in Trinidad and Tobago for selected years

Year	Food and live animal exports (TT$Mn)	Total exports (%)	Food and live animal imports (TT$Mn)	Total imports (%)
1980	176.9	2	707.8	9
1985	88.4	2	764.1	20
1990	363.5	4	859.9	16
1995	882.8	6	1,354.9	12
2001	874.5	3.5	1,831.5	8.3
2003	739.7	2.3	1,919.2	7.8
2004	847.1	2.2	2,208.5	7.2

TT$Mn, millions in $Trinidad and Tobago
Source: Central Statistical Office [3].

7% of total imports in Trinidad and Tobago. If world food prices were to rise, Trinidad and Tobago would face increased costs for food imports. This would have a negative impact on its balance of payments and consequently affect the domestic economy. In addition, the increased prices of imported food commodities would be passed on to consumers, who would be faced with increased prices for their major staples. In line with Engel's law, which states that when a family's income increases, the proportion of its income it spends on food decreases, the impacts of these increased food prices were expected to be felt the most by the lowest-income groups in the society.

Global trade reforms threaten the existence of agreements between the African, Caribbean, and Pacific (ACP) states (which include Trinidad and Tobago) and their traditional trading partners, the countries of the European Union. The loss of preferential access for agricultural export commodities by ACP states would have a significant effect on the economies of these countries. Therefore, although the Uruguay Round Agreements may suggest that global agricultural trade will benefit from trade liberalization and the dismantling of preferences, the impact on individual countries, especially developing countries, may be expected to vary.

A recent study attempted to quantify the impact of the Uruguay Round on poverty [4]; the findings suggest that the net effects on economic growth and poverty are likely to be small. The Uruguay Round was projected to raise 1.3 million people in developing countries above the poverty line of US$1 per person per day, as measured in 1985 purchasing power parity. The estimate of the upper limit of absolute poverty reduction as a consequence of the long-term effects of the Uruguay Round was 15.6 million people (0.5% of the population in the sample of 41 countries). In sub-Saharan Africa, however, the study found that the number of people living at poverty levels could increase by about three-quarters of a million. Overall, the study concluded that the Uruguay Round would cause a net reduction in poverty, but the impact would be small compared with the effects that domestic policies have on growth and poverty.

The present study looks at the effects of the Uruguay Round on a specific developing country, Trinidad and Tobago. We attempt to test the conclusions of the study by Vainio [4] in a small food-import-oriented economy with a relatively small agricultural sector. The paper also briefly examines trends in poverty in Trinidad and Tobago and in the prices of selected major agricultural export commodities from the United States, since the implementation of the Uruguay Round reforms in 1995.

Objectives

The aim of this study is to examine the changes in poverty levels in Trinidad and Tobago that were expected to result from changes in the price levels of major tradable food commodities, subsequent to the removal of trade protection, through reforms resulting from the Uruguay Round, especially by large countries. We hypothesize that these price changes are expected to cause an increase in poverty levels in Trinidad and Tobago, because of the country's orientation toward food importation, an opposite conclusion to that of Vainio [4].

Methods

To test the hypothesis of this study, the prices of sensitive imported food commodities (SIFCs) in Trinidad and Tobago were determined by reference to the consumer price index and food imports of the country. A regression model (referred to as "the poverty model") was developed to predict poverty levels in Trinidad and Tobago with the use of key economic variables, in particular the prices of SIFCs. The world food model (WFM) and the agriculture trade policy simulation model (ATPSM), which are impact models predicting changes in world market prices of major agricultural commodities due to the Uruguay Round, were used to predict changes in the prices of SIFCs attributable to the Uruguay Round. Finally, the changes in prices of SIFCs from the impact models were used to simulate the changes in poverty in Trinidad and Tobago, due to the Uruguay Round, via estimates of elasticities from the poverty model.

Identification of SIFCs

The commodities in **table 2** were recognized as SIFCs in Trinidad and Tobago for two reasons: because they comprise some of the major staple items that constitute the basic food basket in Trinidad and Tobago, a notion supported by the weighting scheme applied to the food section of the retail price index; and because they are largely imported, except for sugar and poultry meat. However, although most poultry meat is produced domestically, almost all of its tradable inputs, such as hatching eggs and feed, are imported.

The poverty model

A log-linear multiple regression model was developed to predict the level of poverty in Trinidad and Tobago using a number of key economic variables that were considered a priori to have major influences on poverty levels. The log-linear model has the advantage of providing direct estimates of the elasticities and is applicable to nonlinear relationships. The variables included in the model are described below.

Poverty (Y)

Given the deficiency in the data on direct estimates of poverty for Trinidad and Tobago, the total number of persons receiving public assistance in Trinidad and Tobago was used as a proxy variable for the number of people living in poverty. In a statement on social services, the following conditions are required for the grant of public assistance:

> An applicant for Public Assistance must be over 18 years of age, unable to earn a living because of illness or injury **and** destitute. Applications can be made in writing or in person to the nearest Social Welfare District Office. Dependents of persons in hospitals and inmates of prisons are provided with facilities for applying in writing for assistance. A Social Welfare Officer will visit the applicant, the case will be assessed and if it is approved, the applicant will qualify to receive public assistance. [6]

Discussions with officers of the Social Welfare Division suggest that the number of people receiving public assistance is the best available measure of poverty in Trinidad and Tobago. However, this measure may underestimate the number of poor in Trinidad and Tobago, since some poor households may fail to carry out the required application procedures.

Inflation (X_1)

The inflation rate was calculated as the percentage rate of change of the index of retail prices. The baseline year for the index was January 2003, for which the index was set at 100. Higher inflation rates are expected to directly reduce the purchasing power of consumers and hence their living standards, raising the level of poverty; thus, one would expect a positive relationship between X_1 and Y.

Unemployment (X_2)

The unemployment rate was calculated as the percentage of the total labor force that was unemployed, as estimated by the central statistical office of the country. In Trinidad and Tobago the levels of poverty were reported to be higher than average in households where the head either was unemployed or had never worked [7]. Therefore, one would expect a positive relationship between X_2 and Y.

Prices of SIFCs (X_3)

X_3 was obtained by deriving a weighted price index (value for 1974 = 100) of the annual prices of all commodities listed in **table 2** [8]. The weights used are also given in **table 2**. Data for this variable were also obtained from the central statistical office [3]. One would expect a positive relationship between X_3 and Y. Higher food prices like inflation would reduce the purchasing power of households and hence their living standards. In the case of higher food prices, as has been argued earlier, the impact will be greater on lower

TABLE 2. Weights of selected items of the retail price index in Trinidad and Tobago

Commodity	Weight[a]
Food	217
Flour (plain white)	7
Rice	6
Powdered milk	9
Poultry (live chicken)	26
Margarine	2
Cooking oil	4
Sugar (washed gray)	3

a. Total weights of retail price index = 1000.
Source: Central Statistical Office [5].

income households. Hence, increases in the prices of SIFCs (X_3) would be expected to increase the applications for public assistance (Y).

Population (X_4)

The population variable was the annual estimate of the population of Trinidad and Tobago [3]. It is often argued that the increasing populations of developing countries lead to increases in poverty because of the increased competition for limited resources. This argument is used to urge the use of birth control in developing countries, and if it holds true, one would expect a positive relationship between X_4 and Y.

Estimation

The poverty model was estimated for the period from 1963 to 2000 by the program EViews 3.1, student version (Irvine, CA, USA: Quantitative Micro Software, LLC, 1994–1999).

Results

The poverty model

The results of the regression analysis are given in **table 3**. For both the Durbin-Watson and the Breusch-Godfrey tests, the null hypothesis of no autocorrelation has to be rejected in favor of positive autocorrelation (the lower limit d_l for the Durbin-Watson test being 1.26). The unemployment (X_2) and prices of SIFCs (X_3) variables were statistically significant, and the population (X_4) and inflation (X_1) variables were not. These results suggest that the size of the population and the rate of inflation did not affect the number of poor people in Trinidad and Tobago, but that unemployment and the prices of SIFCs had significant effects on the number of poor. The linear form of the model also demonstrated positive autocorrelated error terms and a worse fit.

Since the estimated model was to be used for deriving values of the elasticities, procedures for correcting for autocorrelation, such as estimation using first differences, were not considered. The procedure chosen for correcting for autocorrelation was the inclusion of the assumed autocorrelation error structure in the model. Two alternate error specifications were considered, the autoregressive of order one, AR(1), and the moving average of order one, MA(1), by including these terms alternately in the model [9]. The population variable was omitted in these models to economize on the number of degrees of freedom taken up by the regression to facilitate the use of the Breusch-Godfrey test [10]. The model with the MA(1) term gave the better fit and is presented in **table 4.**

Since the estimation of the MA(1) term involves the use of lagged values of the error term, the Breusch-Godfrey test is preferred over the Durbin-Watson test; the Breusch-Godfrey test indicates the absence of autocorrelation in **table 4.**

The results presented in **table 4** indicate that the elasticities of poverty with respect to unemployment (X_2) and prices of SIFCs (X_3) are 0.39 and 0.36, respectively.

TABLE 3. Results of the regression analysis to explain poverty in Trinidad and Tobago

Dependent variable: LOG(Y)				
Method: least squares Included observations: 38 after adjustment of endpoints				
Variable	Coefficient	SE	t-Statistic	Probability
C	8.743411	8.185244	1.068192	0.2932
LOG(X_2)	0.382287	0.152103	2.513334	0.0170
LOG(X_3)	0.396499	0.168276	2.356245	0.0246
LOG(X_4)	–0.201384	1.303955	–0.154441	0.8782
LOG(X_1)	–0.026564	0.043203	–0.614861	0.5429
R^2	0.787123	Mean (dependent variable)		10.31557
Adjusted R^2	0.761320	SD (dependent variable)		0.361540
SE of regression	0.176630	Akaike information criterion		–0.507441
Sum of squared residuals	1.029538	Schwarz criterion		–0.291969
Log likelihood	14.64137	F-Statistic		30.50475
Durbin-Watson statistic	1.091041	Probabililty (F-statistic)		0.000000
(Observations)*R^2 (Breusch-Godfrey test)	7.225707	Probability		0.026975

* Signifies the product of the two terms

TABLE 4. Results of the regression analysis to explain poverty in Trinidad and Tobago with correction for autocorrelation

Dependent variable: LOG(*Y*) Method: least squares Included observations: 38 after adustment of endpoints				
Variable	Coefficient	SE	*t*-Statistic	Probability
C	7.470106	0.476082	15.69080	0.0000
LOG(X_2)	0.389947	0.172442	2.261326	0.0305
LOG(X_3)	0.360257	0.049392	7.293825	0.0000
LOG(X_1)	–0.016151	0.043829	–0.368490	0.7149
MA(1)	0.422687	0.185462	2.279100	0.0293
R^2	0.821561	Mean (dependent variable)		10.31557
Adjusted R^2	0.799932	SD (dependent variable)		0.361540
SE of regression	0.161713	Akaike information criterion		–0.683907
Sum of squared residuals	0.862987	Schwarz criterion		–0.468435
Log likelihood	17.99423	*F*-Statistic		37.98419
Durbin-Watson statistic	1.680959	Probabililty (*F*-statistic)		0.000000
(Observations)*R^2 (Breusch-Godfrey test)	1.112435	Probability		0.573374

* Signifies the product of the two terms

Impact models

Various models have assessed the likely impact of the Uruguay Round on agriculture globally and in Latin America and the Caribbean in particular [11]. These impact models include the WFM [12], the rural-urban north-south (RUNS) model [13], the ATPSM of the United Nations Conference on Trade and Development (UNCTAD) [14], the multiregional global trade model (MRT) of Harrison et al. [15], and a computable general equilibrium (CGE) model of Francois-McDonald-Nordstrom (FMN) [16].

In this study, the WFM and ATPSM impact models were used, because they provided predictions for changes in world market prices of agricultural commodities in 2000. The ATPSM and the WFM are multicommodity partial equilibrium models that cover 12 agricultural commodities for 145 and 130 countries, respectively. These two impact models incorporated the Uruguay Round commitments of countries to determine the impact of these commitments on key indicators, especially on world market prices [17]. The four key (and quantifiable) commitments were the tariffication of nontariff barriers (especially licenses and quotas) and tariff reduction; allowing minimum access to domestic markets; reduction of export subsidies; and reduction of domestic support measures, such as input subsidies and support prices. In general, the models simulated the effect of the Uruguay Round by introducing the commitments made by individual countries in the four key areas into multicommodity partial equilibrium models and then determining the impact of these changes on the indicators (especially world market prices for commodities).

The ATPSM simulated changes in all four key commitments by countries, whereas the WFM did not incorporate domestic support reduction commitments, partly because it was considered that such reductions would not be binding in most cases. The ATPSM provided two separate simulations, referred to as "scenarios." In scenario 1, countries not belonging to the Organization for Economic Cooperation and Development (OECD) were assumed not to respond to world market price changes, and in scenario 2 it was assumed that these countries do respond.

Table 5 gives the projected percentage changes in the world market prices of SIFCs simulated from the two impact models used in this study. The two models differed slightly in the specifications of commodities, in that the WFM had one aggregate category for oils and fat, whereas the ATPSM had two categories, vegetable oils and oil seeds. Only vegetable oils were included in this analysis for the ATPSM, since these

TABLE 5. Impact models showing projected percent changes in world market prices of SIFCs due to the Uruguay Round

		ATPSM	
Product	WFM	1	2
Wheat	7	8.6	1.0
Rice	7	9.6	0.7
Poultry	8	9.3	4.9
Dairy products	7	7.9	4.5
Sugar	—	11.3	4.5
Fats and oils	4	—	—
Vegetable oils	—	5.9	2.5

SIFC, sensitive imported food commodities; WFM, world food model; ATPSM, agriculture trade policy simulation model
Source: Food and Agriculture Organization [18].

were considered a commodity directly consumed by households. The WFM also did not include sugar as a distinct category [17].

The mean percentage price changes of the SIFCs from the models were obtained from **table 5** and are presented in **table 6**, which shows that ATPSM scenario 1 predicts the highest increase (8.77%) in prices of the SIFCs for the year 2000. However, in ATPSM scenario 2, in which the non-OECD countries respond to the new economic conditions of higher prices by expanding production, the model predicts that the world market prices will increase moderately by 3.02%. The WFM predicts a price increase between the two limiting positions of 6.60%.

Poverty prediction

The results of the poverty model were used to carry out the simulations of the changes in poverty levels that would occur because of the changes in the prices of SIFCs given in **table 5**. These simulated predictions are given in **table 6**. The projected mean percentage price changes for the SIFCs are multiplied by the elasticity of poverty (*Y*) with respect to X_3 (0.36), to obtain the projected percentage changes in poverty levels. These percentage changes are also expressed in terms of the number of poor in **table 6**, based on the mean number of poor (*Y*) in **table 4** (30,199).

The results for the models show varying degrees of projected increases in poverty levels as a consequence of the Uruguay Round agricultural reform commitments. As expected, ATPSM scenario 1, which assumes no response from non-OECD countries, indicates that poverty levels could increase by as much as 3.2% if prices were to increase by 8.8%. In ATPSM scenario 2, with a response from non-OECD countries, the poverty level is predicted to increase by only about 1.1%.

TABLE 6. Projected changes in poverty levels due to changes in world market prices of SIFCs resulting from the Uruguay Round

Model	Mean change in price of SIFCs (%)	Change in poverty level (%)[a]	Change in number of poor
WFM	6.60	2.38	719
ATPSM 1 (without non-OECD response)	8.77	3.16	954
ATPSM 2 (with non-OECD response)	3.02	1.09	329

SIFCs, sensitive imported food commodities; WFM, world food model; ATPSM, agriculture trade policy simulation model; OECD, Organization for Economic Cooperation and Development.
a. Calculated as the value in column 2 multiplied by 0.36.

The WFM predicts an increase in poverty, as defined in this study, of 2.38%, or 719 persons.

Recent trends in poverty in Trinidad and Tobago and prices of selected agricultural exports from the United States

This section presents recent trends in poverty (as defined in this study) in Trinidad and Tobago and price trends for selected agricultural products exported from the United States, the major source of food imports (and of all imports) for Trinidad and Tobago, to determine what trends are emerging after the implementation of the Uruguay Round trade reforms in 1995.

As mentioned earlier, the level of poverty in this article is measured by the total number of persons receiving public assistance. **Figure 1** shows the movement of the poverty variable between 1955 and 2002 according to data obtained from the Central Statistical Office [3].

Figure 1 shows that after peaking in 1989, the total number of people receiving public assistance fell, especially after 1995. In fact, the figure in 2000 was less than half that in 1989. The information in **figure 1** conforms to the results of the regression analysis, which suggested that the Uruguay Round reforms would not have led to a significant increase in the level of poverty in Trinidad and Tobago.

Figure 2 shows the average price of cereals, the major agricultural export from the United States, from 1978 to 2004. The price peaked at US$0.18/kg in 1996 and fell steadily through 2000. By 2004, the price of cereals had returned to the 1997 level but not to the 1996 level. **Figure 3** shows the average price of poultry meat exported from the United States from 1978 to 2004. The export price of poultry meat peaked at US$1.22/kg in 1981 and has been below that price level since then.

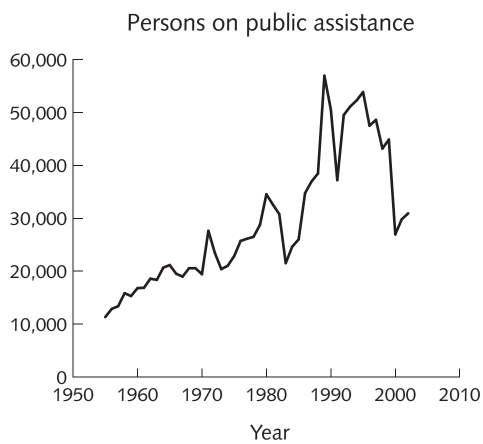

FIG. 1. Persons on public assistance in Trinidad and Tobago, 1955–2002.
Source: Central Statistical Office [3]

By 1995 the price had fallen to US$0.92. After 1996, the price kept falling, reaching $0.65 by 2002. The price had risen to $0.83 by 2004.

Discussion

The Uruguay Round produced the most fundamental reform in the world trading system since the establishment of the General Agreement on Tariffs and Trade (GATT) in 1947. The Agreement on Agriculture seeks to establish a liberalized global market for agricultural products by reducing and eventually eliminating trade barriers and distortions.

The simulation carried out in this study based on impact and poverty models support the hypothesis that any increases in the prices of sensitive imported food commodities (SIFCs) due to the Uruguay Round trade reforms should have led by 2000 to an increase in poverty levels in Trinidad and Tobago. In other words, there should have been a positive relationship between the two variables. The increases in poverty levels were predicted to be very small—on the order of less than 4%. However, any such increases in the prices of SIFCs would have reduced the level of welfare of the entire society of Trinidad and Tobago (real income effect), and the effects would have been greatest among the poorest households in the economy.

The study also examined the movements in the number of poor in Trinidad and Tobago from 1955 to 2003 as measured by the number of persons receiving public assistance. The study also examined recent trends in prices for major agricultural products exported from the United States. The analysis showed that there has been, in fact, a decline in poverty (as defined earlier) since 1996. The prices of the major agricultural exports from the United States (cereals and poultry meat) have also been falling since 1995. Hence, in keeping with the positive relationship estimated in the poverty model, the fall in U.S. export prices should have influenced the fall in poverty levels that has been observed in Trinidad and Tobago, since the United States is the principal source of agricultural imports to Trinidad and Tobago.

Of some interest is the scenario of falling export prices for major agricultural commodities from the United States. This scenario would seem to suggest that by one means or another, the major developed countries may have been able to avoid reducing the level of support they provide to their domestic agricultural sectors [11].

These results are consistent with those of Sharma, who noted that, even though it is difficult to come to definite conclusions because of "there being only four years of experience with the implementation of the Uruguay Round and also because of other developments taking place simultaneously, e.g., weather anomalies and macroeconomic events," [11] a recent assessment by the Food and Agriculture Organization (FAO), among others, drew the following conclusions:

» With some exceptions, there was little evidence that the Uruguay Round had an impact on levels of income and the volume of trade and prices on world markets; and
» There was little evidence of much change in world price instability.

The following reasons were advanced for these conclusions:

» In-country commitments were not considered to be particularly deep in the first place;
» Markets in developed countries have been in the past open to tropical products that do not compete with domestic products as well as some other products

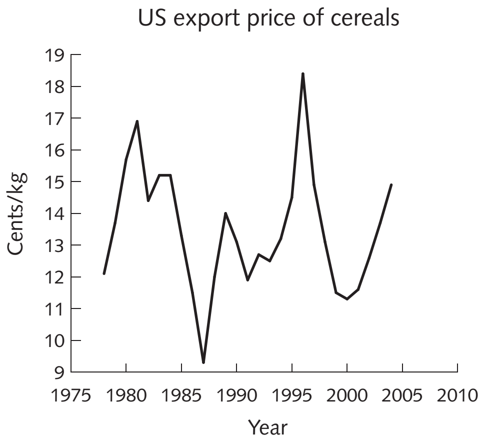

FIG. 2. Average export price of cereals from the United States, 1978–2004
Source: Food and Agriculture Organization [18]

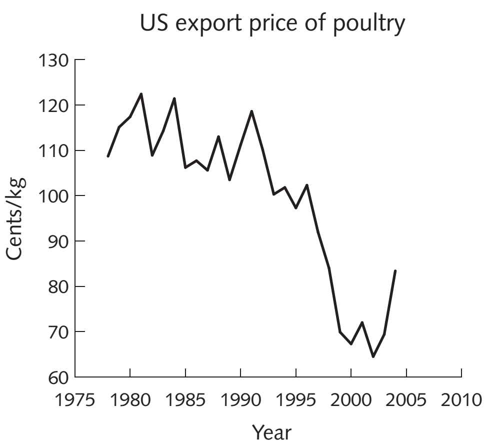

FIG. 3. Average export price of poultry from the United States, 1978–2004
Source: Food and Agriculture Organization [18]

through preferential access. However, with some exceptions, the Uruguay Round did not open up the developed-country markets any more than they had been in the past;

- With some exceptions, the Uruguay Round-led market access commitments have not opened most developing-country markets to significant import competition. In some cases, however, such increased imports by developing countries have caused reduced domestic production in the developing countries.
- It is also equally unlikely that the Uruguay Round restrictions on domestic support have constrained public spending on subsidies; in fact, the main constraints to subsidization may have come instead from domestic shortages of resources for such subsidies.

Conclusions

The Uruguay Round trade reforms for agriculture do not seem as yet to have led to the predicted rise in the prices of world food exports. The case of export prices for major food commodities from the United States supports this conclusion. This study has also shown that any changes in the prices of SIFCs that can be predicted would only cause minimal effects on poverty in Trinidad and Tobago.

References

1. Kaukab RS. What can a developing country expect from WTO 2—From a food importing country's perspective? Agric Rural Dev 2000;7:58–60.
2. Central Statistical Office. Gross domestic product, Trinidad and Tobago, 1985 and 2000. Available at: http://cso.gov.tt/statistics/accounts/default.asp. Accessed 7 June 2006.
3. Central Statistical Office. Overseas trade report and annual statistical digest. Port of Spain, Trinidad and Tobago: Central Statistical Office, Ministry of Planning and Development, 1955–2002.
4. Vainio M. Quantifiable impact of the Uruguay Round on poverty. Dev Policy Rev 1996;14:37–49.
5. Central Statistical Office. The index of retail prices. Port of Spain, Trinidad and Tobago: Central Statistical Office, Ministry of Planning and Development, 1993.
6. Government of the Republic of Trinidad and Tobago, Ministry of Public Administration and Information. Social Services. http://www.nalis.gov.tt/Government/Social_services.html. Accessed 7 June 2006.
7. World Bank. Trinidad and Tobago: poverty and unemployment in an oil-based economy. Washington DC: World Bank, 1995.
8. Lipsey RG, Chrystal KA. Economics (10th edition). New York: Oxford University Press, 2004.
9. Kmenta J. Elements of econometrics. New York: Macmillan Publishing Company, 1986.
10. Ramanathan R. Introductory econometrics with applications. Fort Worth, Tex, USA: Harcourt College Publishers, 2002.
11. Sharma R. The Uruguay Round and WTO 2—a resume and outlook for the developing countries in agriculture. Agriculture and Rural Development 2000;7:47–9.
12. Food and Agriculture Organization. Impact of the Uruguay Round on Agriculture—methodological approach and assumptions. Document ECS/M/95/1, April 1 1995. Rome: Food and Agriculture Organization, 1995.
13. Goldin IO, Van der Mensbrugghe D. The Uruguay Round: an assessment of economy-wide and agricultural reforms. Paper presented at The Uruguay Round and the Developing Economies, World Bank conference, 26–27 January 1995. Washington, DC: World Bank, 1995.
14. United Nations Conference on Trade and Development (UNCTAD). Handbook on the UNCTAD Agricultural Trade Policy Simulation model. Geneva: United Nations Conference on Trade and Development (UNCTAD), November 2002. Available at: http://www.fao.org/regional/lamerica/prior/comagric/negocia/atpsm/manual.pdf#search='ATPSM%20model%20Unctad. Accessed 22 June 2006.
15. Harrison GW, Tarr D, Rutherford TF. Quantifying the outcome of the Uruguay Round. Finance and Development 1995;32:38–41.
16. Francois JF, McDonald B, Nordstrom H. Assessing the Uruguay Round. Paper presented at The Uruguay Round and the Developing Economies, World Bank conference, 26–27 January 1995. Washington, DC: World Bank, 1995.
17. Sharma R, Konandreas P, Greenfield J. Synthesis of results on the impact of the Uruguay Round on the global and LAC agriculture. Implementing the UR agreement in Latin America—the case of agriculture. FAO/World Bank Workshop. Rome: Food and Agriculture Organization, 1997.
18. Food and Agriculture Organization. FAOSTAT, FAO Statistical databases.http://faostat.fao.org. Accessed 7 June 2006.

Impact of a multiple-micronutrient food supplement on the nutritional status of schoolchildren

Malavika Vinod Kumar and S. Rajagopalan

Abstract

Background. Multiple-micronutrient deficiencies exist in many developing nations. A system to deliver multiple micronutrients effectively would be of value in these countries.

Objective. To evaluate the delivery of multiple micronutrients through the food route. The goal was to test the stability of the supplement during cooking and storage and then to test its bioefficacy and bioavailability in residential schoolchildren 5 to 15 years of age.

Methods. A pre- and post-test design was used to study children 5 to 15 years of age, with an experimental and a control group. The experimental group (n = 211) consisted of children from two residential schools, and the control group (n = 202) consisted of children from three residential schools. The experimental group received a micronutrient supplement containing vitamin A, vitamin B_2, vitamin B_6, vitamin B_{12}, folic acid, niacin, calcium pantothenate, vitamin C, vitamin E, iron, lysine, and calcium daily for 9 months. There was no nutritional intervention in the control group.

Children in the experimental and control groups were matched by socioeconomic status, age, and eating habits at baseline. All of the children in the experimental and control schools were dewormed at baseline, after 4 months, and at the endpoint. Biochemical measurements (hemoglobin, serum vitamin A, serum vitamin E, serum vitamin B_{12}, and serum folic acid) were measured at baseline, after 4 months, and at the endpoint (after 9 months). The heights and weights of the children were also measured at baseline and endpoint. Serum vitamins A and E were measured in a subsample of 50% and vitamin B_{12} and serum folic acid measured in a subsample of 25% of the children.

Results. In the experimental group, the mean gains in hemoglobin, serum vitamin A, serum vitamin E, serum vitamin B_{12}, and serum folic acid over 9 months were 0.393 g/dL, 6.0375 µg/dL, 1037.45 µg/dL, 687.604 pg/mL, and 1.864 ng/mL, respectively. In the control group, the mean losses in hemoglobin and serum vitamin A over 9 months were 0.9556 g/dL and 10.0641 µg/dL, respectively, and the mean gains in serum vitamin E, vitamin B_{12}, and folic acid were 903.52 µg/dL, 233.283 pg/mL, and 0.0279 ng/mL. The mean gain in all biochemical measurements was significantly higher ($p < .05$) in the experimental group than in the control group.

Conclusions. Vitamin A, vitamin E, vitamin B_{12}, folic acid, and iron are bioavailable from the multiple-micronutrient food supplement used in this study. This method of micronutrient delivery has been beneficial. We believe the study intervention was beneficial because of small doses of the micronutrients added but delivered many times through meals throughout the day, over a period of 9 months.

Key words: Food delivery, multiple-micronutrient supplementation

Introduction

Micronutrient deficiencies in developing countries are a consequence of the plant-based cereal diets typically consumed in these areas [1, 2]. Dietary phytate inhibits the absorption of many micronutrients, notably iron and zinc. Micronutrient deficiencies in infancy can cause impairments in physical development and cognition that may be irreversible [3–5]. Iron and iodine deficiencies affect more than 30% of the global population [6]. It has been suggested that supplementation with multiple micronutrients may be the best way to improve the nutritional status of malnourished

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populations [7]. Earlier studies targeted children within the family. Packaged in single-serving sachets, the fortificant (microencapsulated ferrous fumarate) is designed to be sprinkled onto complementary cooked foods, to be served to children, one sachet per meal. A randomized, controlled trial demonstrated that microencapsulated ferrous fumarate sprinkles were as efficacious as ferrous sulfate drops in the treatment of anemia in infants 6 to 18 months of age [8].

There are no data on the effects of adding multiple-micronutrient supplements to food during cooking in order to make the micronutrients available to the entire family. For this method to be successful, the micronutrients should not change the color, odor, or taste of the food, should be stable at cooking temperatures, and should be bioavailable. With these concepts kept in mind, a multiple-micronutrient food supplement was developed that contained vitamin A, vitamin B_2, vitamin B_6, vitamin B_{12}, folic acid, niacin, calcium pantothenate, vitamin C, vitamin E, iron, lysine, and calcium. The intention was that the supplement sprinkled on the food during cooking would supply these nutrients to the entire family. The advantage of this method of nutrient delivery is that all the family members would benefit from the supplement.

The current study tested the acceptability of the supplement during cooking and storage and tested for the bioavailability of five important micronutrients: iron, vitamin A, vitamin E, vitamin B_{12}, and folic acid, as well as other B-complex vitamins, in the target group of children in residential schools. If the food supplement was found to benefit the children by improving their levels of serum vitamin A, serum vitamin E, hemoglobin, serum vitamin B_{12}, and serum folic acid, we could conclude that this method of micronutrient delivery was feasible, setting the stage for conducting larger-scale community studies.

This study aimed to evaluate the delivery of multiple micronutrients through the food route. The goal was to test the stability of the supplement during cooking and storage and then to test its bioefficacy and bioavailability in residential schoolchildren 5 to 15 years of age.

Methods

Subjects

The study had a pre- and post-test design with experimental and control groups. Two residential schools (A and B) were randomly selected as the experimental schools and three other residential schools (C, D, and E) as the controls from residential schools in the city of Chennai, Tamilnadu, South India. Schools A through E were chosen randomly from a computer-generated list and a random table. Study schools were chosen prior to randomization, after a survey of residential schools was undertaken, because children at these schools had the lowest intake of outside (unfortified) cooked food and the schools had the fewest holidays when the children were allowed to go home, which would cause less disruption in the study. Children in the experimental schools were supplied with the multiple-micronutrient food supplement. Children in the control group, except those with severe anemia and serum vitamin A deficiency, who were treated for ethical reasons and excluded from the study, received no intervention other than deworming. The study began when the schools reopened after the summer vacation and continued for 9 months until the schools closed again for the next summer vacation. There were 211 children in the experimental group (169 in school A and 42 in school B) and 202 children in the control group (90 in school C, 70 in school D, and 42 in school E).

The experimental and control groups of children were selected after establishing their homogeneity in terms of age and socioeconomic status; the families of all the children had a monthly income of less than Rs1,500 ($US30). The supplement was provided to the experimental schools every month, and its use was monitored by counting the number of packets remaining in the school every week.

Manufacture and administration of supplement

The multiple-micronutrient food supplement was manufactured in a ribbon blender (Bhuvaneshwari Engineering, Chennai, India) at 50 rpm. The homogeneity of the supplement's micronutrient content was established at the manufacturing stage by assessing the micronutrient content in different parts of the blender. It was determined that all of the micronutrients were uniformly and homogeneously distributed within the product.

The dosage was 1 g of supplement per child per day. The required daily quantity for all the children in a specific school was premeasured, packed, sealed, and delivered to the schools, so that one packet could be cut open each day and added to the food during cooking, throughout the day. The supplement was dissolved in water and added to liquid food in the final stages of cooking, and it was sprinkled onto solid foods. The cooking staff of both the experimental schools certified that the supplement did not change the color or taste of any food. Each school has a central kitchen where the food is prepared and a central dining room where the resident children eat.

It was generally observed that there was no waste of the food prepared in the schools; all prepared food was consumed. The children were served the quantity of food they wished, and there was no food left over on the plate.

Blood collection and storage

Blood samples (5 mL) were drawn from each child at the schools and transferred to the laboratory within 2 hours of collection. During collection of these samples, 500 μL was transferred into vials with ethylenediaminetetraacetate (EDTA) as an anticoagulant. The hemoglobin measurements were performed on these samples within a few hours of blood collection. The remaining 4.5 mL of blood was transferred into vials covered with black paper to prevent exposure to light, and the blood was allowed to clot. Serum separation was performed and the samples were frozen at –20°C within a few hours after collection of blood. Analysis of serum for folic acid and vitamins B_{12}, A, and E was completed within a month after blood collection. The samples were processed in a dark room with yellow lighting to prevent retinol isomerization.

Biochemical measurements

The concentrations of blood hemoglobin and serum vitamin A, vitamin E, vitamin B_{12}, and folic acid were measured. Hemoglobin was measured in all the children in both groups. Serum vitamin A was measured by high-performance liquid chromatography (HPLC) only in those children who were identified as having vitamin A deficiency by physicians who checked the eyes of the children for clinical signs of vitamin A deficiency, such as Bitot's spots or xerosis. Eighty-two children in the experimental group and 84 children in the control group had clinical signs of vitamin A deficiency. At baseline, only eight children in the experimental group had serum vitamin A levels under 20 μg/dL, the cutoff for vitamin A deficiency, as defined by the International Vitamin A Consultative Group (IVACG). Seven children in the control group had serum vitamin A levels under 20 μg/dL. For ethical reasons, these children were given therapeutic tablets of vitamin A to combat the deficiency and were excluded from further analysis. Analysis of data for serum vitamin A and E was performed only for the remaining 77 children in the control group.

Serum folic acid and vitamin B_{12} were measured in the 44 children in the experimental group and the 54 children in the control group who had the lowest hemoglobin levels. All biochemical measurements were carried out before the start of the study (baseline), 4 months after the start of the study (midpoint), and 9 months after the start of the study (endpoint).

Hemoglobin was estimated by the cyanmethemoglobin method with a spectrophotometer [9]. Serum vitamin A and E were measured by a rapid, reverse-phase HPLC method for simultaneous determination of retinol and α-tocopherol (vitamin E) [10]. Vitamin B_{12} and folic acid assays were performed with a paramagnetic particle, chemiluminescent immunoassay for the quantitative determination of levels in human serum using the Access immunoassay system (Beckman Instruments, Brea, CA, USA).

Validation of biochemical measurements

Hemoglobin levels were measured in duplicate in all of the samples; serum vitamin A, vitamin E, vitamin B_{12}, and folic acid were measured in duplicate in 10% of the samples. For validation of vitamin A measurements, the average of the two values was calculated and the percentage of deviation from the average determined. The permissible percentage deviation from average was 10% for vitamin A levels over 30 μg/dL and 15% for vitamin A levels between 15 and 30 μg/dL. The vitamin A levels of the subjects were within these averages. For validation of vitamin E measurements, the average of the two values was calculated and the percentage of deviation from the average determined. In all three rounds, the percentage of deviation from the average values did not exceed 10%.

Anthropometric measurements

The heights and weights of the children in the experimental and control groups were recorded at baseline and 9 months.

Deworming

Both the experimental and the control children were given a tablet of albendazole (400 mg) at baseline and at 4 and 9 months later. Deworming was done to ensure that there were no worms competing for the micronutrients and that the intestinal tract was clear for absorption of the micronutrients [11, 12].

Clinical assessment

Clinical assessment of angular stomatitis, a condition caused by deficiencies of B-complex vitamins, was conducted by physicians before the start of the study and after 9 months of intervention.

Administration of iron

In most of the studies reviewed in the literature, iron was administered in the form of ferrous sulfate tablets for periods ranging from 2 to 8 months [13–16]. In our study, the experimental group received 10 mg of elemental iron in the multiple-micronutrient supplement every day for 9 months. The iron was chelated ferrous sulfate along with malic acid as a biopromoter added. Chelated iron compounds have a much higher bioavailability than inorganic iron compounds. The studies reviewed in the literature mentioned ferrous sulfate, ferrous fumarate, and other iron compounds but did not mention chelated iron compounds [17–20].

Measurement of stability of the supplement

To determine the stability of the supplement, its composition was analyzed initially, after adding it to an Indian dish—sambar (lentil soup) and cooking it for 30 minutes, and after storage for 10 months at 30°C and 45% humidity. The required aliquots from the lentil soup were taken for the analysis of micronutrients. Six samples were taken before and after cooking. Micronutrient composition was analyzed by methods described in the Indian Pharmacopoeia [21].

Statistical analysis

Statistical analysis was performed with SPSS 11.0 (SPSS Inc., Chicago IL, USA) and Microsoft Excel 2000 (Microsoft Corp., Seattle WA, USA). Analysis of variance (ANOVA) was used to compare the micronutrient status of the experimental and control groups and within the groups over time.

Ethical issues

The study was approved by the institutional review board of the Sundar Serendipity Foundation. Informed written consent was obtained from the school directors, and informed oral consent was obtained from the parents or legal guardians of all of the children. The parents of the children in the experimental schools were informed about the use of the supplement in all meals served in the schools and about the blood tests to be performed. The parents of the children in the control schools were informed that blood tests would be performed on all of the children and that children with severe anemia (hemoglobin < 8 g/dL) or biochemical vitamin A deficiency (serum retinol < 20 μg/dL) would be treated immediately. Anemic children were treated with ferrous sulfate tablets (60 mg elemental iron) for a period of 3 months. Serum vitamin A-deficient children were treated with vitamin A tablets. These treated children were excluded from the study. All children who were anemic at the end of the study were treated with ferrous sulfate (60 mg elemental iron) daily for a period of 3 months. All children in the five schools were invited to participate in the study and all parents or legal guardians gave consent.

Results

Stability of the supplement

All micronutrients except vitamin A were very stable after 30 minutes of cooking and 10 months of storage (**table 1**). A drop of up to 20% in the potency of vitamin A was observed during cooking, so the product was formulated to compensate for this loss of vitamin A.

Biochemical and clinical effects of the intervention

At baseline, the experimental and control groups had similar serum levels of vitamin E, vitamin B_{12}, and folic acid, but the hemoglobin level was significantly ($p < .05$) lower and the serum vitamin A level was significantly higher in the experimental group than in the control group. The differences between the groups could be due to differences between the schools in the diets consumed or in other, unknown, factors. Therefore all the biochemical measurements were analyzed schoolwise to study the impact of the supplementation.

At the end of 9 months of intervention there were significant ($p < .05$) improvements in the mean values of all of the biochemical measurements in the experimental group (**table 2**). This pattern was also seen when the results from each school were individually analyzed (**table 3**). In the control group, there were significant decreases from baseline to 9 months in mean hemoglobin and vitamin A levels, significant improvements in vitamins E and B_{12} levels, and no significant change in folic acid levels (**table 2**). This pattern was also seen

TABLE 1. Composition of the multiple-micronutrient food supplement and its stability during cooking and storage)

	Amount in the supplement		
Micronutrient	Initial amount	After 30 min cooking	After 10 mo storage
Vitamin A (IU/g)	3,000.00	2,425.00	2,326.00
Vitamin B_2 (mg/g)	1.00	1.00	1.00
Calcium pantothenate (mg/g)	1.00	1.00	1.00
Niacin (mg/g)	15.00	15.00	14.91
Vitamin B_6 (mg/g)	1.00	1.00	1.00
Folic acid (μg/g)	100.00	99.49	99.27
Vitamin B_{12} (μg/g)	1.00	1.00	1.00
Vitamin E (IU/g)	30.00	29.85	30.00
Vitamin C (mg/g)	30.00	28.01	23.96
Iron (mg/g)	10.00	10.00	10.00
Lysine (mg/g)	250.00	243.80	246.51
Calcium (% of weight)	13.75	13.75	13.75

when the results from each school were individually analyzed (**table 3**). At 9 months, the mean values of all the biochemical measurements except vitamin E were significantly higher in the experimental group than in the control group (**table 2**).

To determine whether the intervention had any effect on biochemical measurements, the changes in all of the biochemical measurements from baseline to 9 months were compared between the experimental and control groups (**table 4**). The increase was significantly greater ($p < .05$) in the experimental group than the control group for all measurements. This result demonstrated the bioabsorption of iron, vitamin A, vitamin E, vitamin B_{12}, and folic acid from the supplement.

The prevalence of angular stomatitis at the start of the study was 16.2% in the experimental group and 22.56% in the control group. At the end of the study, angular stomatitis had completely disappeared in the experimental group, whereas the prevalence remained at 25.40% in the control group (**table 2**).

Enhancement of stability and shelf life of the micronutrients

The supplement did not change the odor or color of any foods during cooking. The micronutrients in the supplement were also stable during storage and cooking. This was achieved by encapsulating the heat-labile vitamins, such as vitamin C, with food-grade cellulose acetate phthalate to provide a heat-resistant

TABLE 2. Biochemical and clinical measurements of children at baseline and 9-month endpoint (mean ± SD)

	Experimental group			Control group		
Measurement	*N*	Baseline	Endpoint	*N*	Baseline	Endpoint
Hemoglobin (g/dL)	211	10.99 ± 1.41[ab]	11.38 ± 1.06[be]	202	11.32 ± 1.13[ac]	10.35 ± 0.99[ce]
Serum vitamin A (μg/dL)	82	47.18 ± 19.66[ab]	53.33 ± 25.82[be]	77	43.62 ±13.83[ac]	32.08 ± 10.74[ce]
Serum vitamin E (μg/dL)	82	910.90 ± 269.00[b]	1960.00 ± 400.80[b]	77	973.90 ± 314.00[d]	1932.55 ± 575.80[d]
Serum vitamin B_{12} (pg/mL)	44	193.66 ± 84.90[b]	1030.60 ± 1232.00[be]	54	217.29 ± 155.60[d]	440.24 ± 269.00[de]
Serum folic acid (ng/mL)	44	4.87 ± 1.31[b]	6.75 ± 2.17[be]	54	4.92 ± 1.09	5.08 ± 1.69[e]
Angular stomatitis (% of subjects)	211	16.20	0	202	22.56	25.40

a. Values at baseline differed significantly ($p < .05$) between experimental and control groups.
b. Values increased significantly ($p < .05$) in experimental group from baseline to endpoint.
c. Values decreased significantly ($p < .05$) in control group from baseline to endpoint.
d. Values increased significantly ($p < .05$) in control group from baseline to endpoint.
e. Values in experimental group were significantly ($p < .05$) higher than in control group at endpoint.

TABLE 3. Biochemical measurements according to school at baseline and 9-month endpoint (mean ± SD)

	Experimental group				Control group			
Measurement	School	*N*	Baseline	Endpoint	School	*N*	Baseline	Endpoint
Hemoglobin (g/dL)	A	169	11.20 ± 1.40[a]	11.60 ± 0.99[a]	C	90	10.71 ± 0.76[b]	10.38 ± 0.98[b]
	B	42	10.14 ± 1.11[a]	10.54 ± 0.90[a]	D	70	12.14 ± 1.24[b]	9.96 ± 0.93[b]
					E	42	11.34 ± 0.59[b]	10.99 ± 0.78[b]
Serum vitamin A (μg/dL)	A	75	48.36 ± 19.64[a]	54.56 ± 25.45[a]	C	35	36.93 ± 12.34[b]	29.80 ± 9.86[b]
	B	7	34.57± 16.03	40.57± 28.20	D	28	46.83 ± 19.12[b]	34.00 ± 10.37[b]
					E	14	41.00 ± 12.56[b]	32.43 ± 11.84[b]
Serum vitamin E (μg/dL)	A	75	932.64 ± 262.00[a]	1,971.73 ± 398.80[a]	C	35	976.65 ± 303.80[a]	2,071.25 ± 739.00[a]
	B	7	715.77 ± 264.69[a]	1,862.22 ± 428.80[a]	D	28	1,098.30 ± 283.60[a]	1,916.20 ± 362.37[a]
					E	14	699.50 ± 239.30[a]	1,618.57 ± 305.58[a]
Serum vitamin B_{12} (pg/mL)	A	36	202.26 ± 84.40[a]	1,060.31 ± 1,305.00[a]	C	26	253.15 ± 192.70[a]	499.54 ± 341.00[a]
	B	8	169.87 ± 83.00[a]	815.25 ± 462.00[a]	D	16	214.18 ± 122.00[a]	340.25 ± 99.45[a]
					E	12	141.27 ± 56.30[a]	482.42 ± 236.90[a]
Serum folic acid (ng/mL)	A	36	4.73 ± 1.28[a]	6.83 ± 2.33[a]	C	26	4.57 ± 1.07	4.79 ± 1.22
	B	8	5.53 ± 1.36	6.27 ± 1.27	D	16	5.144± 1.04	4.78 ± 1.92
					E	12	5.39 ± 1.06	5.97 ± 1.75

a. Significant improvement ($p < .05$) from baseline to endpoint.
b. Significant decrease ($p < .05$) from baseline to endpoint.

TABLE 4. Changes in biochemical measurements from baseline to 9-month endpoint (mean ± SD)[a]

	Experimental group		Control group	
Measurement	*N*	Change	*N*	Change
Hemoglobin (g/dL)	211	0.393 ± 1.12	202	–0.956 ± 1.33
Serum vitamin A (μg/dL)	82	6.038 ± 25.43	77	–10.064 ± 17.82
Serum vitamin E (μg/dL)	82	1,037.450 ± 393.00	77	903.520 ± 618.50
Serum vitamin B_{12} (pg/mL)	44	687.604 ± 1,110.00	54	233.283 ± 195.20
Serum folic acid (ng/mL)	44	1.864 ± 1.99	54	0.028 ± 1.60

a. The change was significantly ($p < .05$) better in the experimental group than the control group for all measurements.

TABLE 5. Anthropometric measurements of children 5 to 10 years of age at baseline and 9-month endpoint (mean ± SD)

	Experimental group			Control group		
Measurement	*N*	Baseline	Endpoint	*N*	Baseline	Endpoint
Height (cm)	59	118.63 ± 7.07	122.15 ± 7.19	100	117.06 ± 10.59	119.99 ± 10.46
Weight (kg)	59	20.71 ± 3.28	22.53 ± 3.42[a]	100	19.57 ± 4.38	21.22 ± 4.97[a]

a. Values were significantly ($p < .05$) higher in the experimental group than in the control group at endpoint.

coat. Similarly, the B-complex vitamins were coated with glyceryl stearate or other edible waxes or gums to protect them and to mask the unpleasant taste of some B-complex vitamins. Vitamin A is already encapsulated in gum acacia and sugar by the manufacturers. Lysine, vitamin E, and calcium pantothenate were left uncoated. The iron source was ferrous sulfate, with chelating agents and biopromoter added to enhance its bioavailability even in the presence of dietary phytates.

Anthropometric effects

The heights and weights of 197 children in the experimental group and 196 children in the control group were measured at baseline and at 9 months. There were no significant differences between the groups in changes in height or weight from baseline to 9 months. Therefore, we analyzed the data from children 5 to 10 years of age and the data from children 11 to 15 years of age separately. Among children 5 to 10 years of age, the mean weight at the endpoint was significantly greater ($p < .05$) in the experimental group than in the control group, although at baseline there was no significant difference between the mean weights of the two groups (**table 5**). The mean increase in height was 3.525 cm in the experimental group and 2.93 cm in the control group ($p < .05$), but the mean increase in weight did not differ between the groups (**table 6**).

TABLE 6. Changes in anthropometric measurements of children 5 to 10 years of age from baseline to 9-month endpoint (mean ± SD)

Measurement	*N*	Experimental group	*N*	Control group
Height (cm)	59	3.53 ± 1.14[a]	100	2.93 ± 1.38[a]
Weight (kg)	59	1.82 ± 0.93	100	1.65 ± 1.11

a. Values were significantly ($p < .05$) higher in the experimental group than in the control group at endpoint.

Discussion

The aim of this study was to test the efficacy of the delivery of multiple micronutrients in cooked food in residential schools. If the multiple-micronutrient food supplement remained stable during cooking and storage and was efficacious in the improvement of serum biochemical measurements, this study would provide basic evidence that this method of delivery works and should be considered for larger field community trials.

Since multiple micronutrients are responsible for erythropoiesis, earlier studies have shown that in populations where multiple micronutrient deficiencies exist, interventions with single micronutrients alone, such as iron and zinc, are not sufficient to mitigate the deficiencies [22, 23]. Earlier studies have shown that when multiple-micronutrient supplements are administered, it is the iron and zinc that cause linear growth in children [24]. In the present study, there were no significant differences in anthropometric measurements between the experimental and control groups when each group was considered as a whole. However, if the children in the 5- to 10-year age group are studied separately, the increase in height is significantly greater in the experimental group. The difference in the result when the younger age group was considered separately may have been due to the occurrence of growth spurts at different ages.

Another reason for the development of the multiple-micronutrient food supplement is the cost factor. The cost of the supplement is about 45 paise (1 US cent) per person per day. Without lysine, the cost would be only 0.5 US cent per person per day. This is extremely low compared with the cost of multiple-micronutrient tablets. Moreover, focus group discussions with people in Tamilnadu have shown that the people perceive tablets as medicine and would not consume them unless they were sick. When they were educated about the supplement and the need to add it to food during cooking, they readily accepted the concept.

The use of the supplement for 9 months resulted in a significant ($p < .05$) improvement in all biochemical measurements. Clinical signs of angular stomatitis, a condition caused by a deficiency of B-complex vitamins, especially vitamin B_2, completely disappeared in the experimental group, whereas the prevalence of the condition remained the same in the control group. It could be inferred that the B-complex vitamins in general, and vitamin B_2 in particular, were absorbed from the supplement and that the higher level of ingestion of these micronutrients was a factor in the disappearance of angular stomatitis in the experimental group.

The hemoglobin level was significantly ($p < .05$) lower in the experimental group than in the control group at baseline, but at the endpoint it was significantly higher in the experimental group than in the control group. Over the 9-month period, there was a significant increase in hemoglobin level in the experimental group and a significant decline in the control group. This same pattern was seen when each of the schools was individually analyzed. The mean increase in hemoglobin level in the experimental group was 0.393 g/dL, and the mean decrease in hemoglobin level in the control group was 0.9556 g/dL. A statistically significant decline in hemoglobin in children aged 5 to 15 years has been observed elsewhere [25]. It may be due to the insufficient bioavailability of iron from the predominantly vegetarian cereal-based diets of these children or the diversion of iron to myoglobin in the muscles as the children grow. This, however, needs to be verified by conducting further prevalence studies on anemia over a period of 10 months to one year in a similar population.

The serum vitamin A level at baseline was significantly ($p < .05$) higher in the experimental group than in the control group. However, over the 9-month period, vitamin A values significantly increased in the experimental group and significantly decreased in the control group. At endpoint, the mean serum vitamin A level in the experimental group was significantly higher than in the control group. This trend was also seen when each school was individually analyzed. No illness or infection was observed in any of the control schools. The reason for the decline in serum vitamin A in the control schools is unknown, and similar prevalence studies in similar children are warranted.

The normal ranges of serum vitamin B_{12} and E levels are 200 to 950 pg/mL and 500 to 1,800 µg/dL, respectively. The same method (HPLC) was used to measure both vitamins A and E; the times of elution of both of these compounds are a few minutes apart. There was a significant increase in serum vitamins E and B_{12} in both groups. The same trend was seen when the schools were individually analyzed. The increases in the levels of these two vitamins were significantly ($p < .05$) higher in the experimental group than in the control group.

The normal range of serum folic acid levels is 3 to 17 ng/mL. In the experimental group, there were three children with serum folic acid levels < 3 ng/mL at baseline, and there were none in the experimental group at endpoint. In the control group, there were three children with serum folic acid < 3 ng/mL at baseline, and at endpoint there were two children with serum folic acid < 3 ng/mL. There was no significant difference between the experimental and control groups in serum folic acid at baseline. There was no change in folic acid levels in the control group, whereas there was a significant increase ($p < .05$) in the experimental group at endpoint. The same pattern was seen when the data from each school were individually analyzed.

These trends in biochemical measurements demonstrate the bioavailability of the micronutrients in the supplement. Similar improvements in vitamin A and hemoglobin levels have been seen in other trials in which multiple-micronutrient tablets have been administered to schoolchildren [26–28]. Thus, it can be concluded that the delivery of multiple micronutrients by the method of supplementation described in this study, i.e., through the food route, is as efficient as the conventional method of supplementation through tablets.

Conclusions

Vitamin A, vitamin E, vitamin B_{12}, folic acid, the other B vitamins, and iron are bioavailable from a multiple-micronutrient food supplement added to food during cooking. Long-term community trials should be undertaken to establish the efficacy of this pathway of supplementation to combat micronutrient malnourishment.

References

1. World Health Organization (2000). Malnutrition. The global picture. Geneva: WHO.
2. United Nations Children's Fund.(2000). The state of the world's children 2000. New York: UNICEF.
3. Lozoff B, Jiminez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. N Engl J Med 1991;325:687–94.
4. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. J Nutr 2001;131:649S–66S; discussion 666S–8S.
5. Hautvast JLA, Tolbloom JJ, Kafwembe EM, Musonda RM, Mwanakasale V, van Staveren WA, van't Hof MA, Sauerwein RW, Willems JL, Monnens LA. Severe linear growth retardation in rural Zambian children: the influence of biological variables. Am J Clin Nutr 2000;71:550–9.
6. WHO/UNICEF/UNU. IDA: Prevention, assessment and control. Report of a joint WHO/UNICEF/UNU consultation. Geneva: WHO; 1998:1–9.
7. UNICEF/UNU/WHO/MI. Preventing iron deficiency in women and children. Technical consensus on key issues. The Micronutrient Initiative; 1999.
8. Zlotkin S, Arthur P, Antwi KY, Yeung G. Treatment of anemia with microencapsulated ferrous fumarate plus ascorbic acid supplied as sprinkles to complementary (weaning) foods. Am J Clin Nutr 2002;76:691–3.
9. Azim W, Parveen S. Comparison of photometric cyanmethemoglobin and automated methods for hemoglobin estimation. J Ayub Med Coll Abbottabad 2002;14(3):22–3.
10. Miller KW, Lorr NA, Yang CS. Simultaneous determination of plasma retinol, alpha-tocopherol, lycopene, alpha-carotene, and beta-carotene by high-performance liquid chromatography. Anal Biochem 1984;138:340–5.
11. Olsen A, Thiong'o FW, Ouma JH, Mwaniki D, Magnussen P, Michaelsen KF, Friis H, Geissler PW. Effects of multimicronutrient supplementation on helminth reinfection: a randomized, controlled trial in Kenyan schoolchildren. Trans R Soc Trop Med Hyg 2003;97:109–14.
12. Taylor M, Jinabhai CC, Couper I, Kleinschmidt I, Jogessar VB. The effect of different anthelmintic treatment regimens combined with iron supplementation on the nutritional status of schoolchildren in KwaZulu-Natal, South Africa: a randomized controlled trial. Trans R Soc Trop Med Hyg 2001;95:211–6.
13. Lozoff B, Brittenham GM, Wolf AW, McClish DK, Kuhnert PM, Jimenez E, Jimenez R, Mora LA, Gomez I, Krauskoph D. Iron deficiency anemia and iron therapy effects on infant developmental test performance. Pediatrics 1987;79:981–95.
14. Walter T, De Andraca I, Chadud P, Perales CG. Iron deficiency anemia: adverse effects on infant psychomotor development. Pediatrics 1989;84:7–17.
15. Idjradinata P, Pollitt E. Reversal of developmental delays in iron-deficient anaemic infants treated with iron. Lancet 1993;341(8836):1–4.
16. Soemantri AG, Pollitt E, Kim I. Iron deficiency anemia and educational achievement. Am J Clin Nutr 1985;42:1221–8.
17. Heywood A, Oppenheimer S, Heywood P, Jolley D. Behavioral effects of iron supplementation in infants in Madang, Papua New Guinea. Am J Clin Nutr 1989;50(3 suppl):630–7; discussion 638–40.
18. Soewondo S, Husaini M, Pollitt E. Effects of iron deficiency on attention and learning processes in preschool children: Bandung, Indonesia. Am J Clin Nutr 1989;50:667–74.
19. Seshadri S, Gopaldas T. Impact of iron supplementation on cognitive functions in preschool and school aged children: the Indian experience. Am J Clin Nutr 1989; 50(3 suppl):675–84; discussion 685–6.
20. Groner JA, Holtzman NA, Charney E, Mellitts ED. A randomized trial of oral iron on tests of short-term memory and attention span in young pregnant women. J Adolesc Health Care 1986;7:44–8.
21. Indian Pharmacopoeia 1996, published by Publication and Information Directorate, CSIR, Ministry of Health and Family Welfare, Government of India.
22. Allen LH, Rosado JL, Casterline JE, Lopez P, Munoz E, Garcia OP, Martinez H. Lack of hemoglobin response to iron supplementation in anemic Mexican preschoolers with multiple micronutrient deficiencies. Am J Clin Nutr 2000;71:1485–94.
23. Allen LH. Nutritional influences on linear growth: a general review. Eur J Clin Nutr 1994;48(suppl 1):S75–89.
24. Bhandari N, Bahl R, Taneja S. Effect of micronutrient supplementation on linear growth of children. Br J Nutr 2001;85(suppl 2):S131–7.
25. Madhavan Nair K, Brahmam GNV, Ranganathan S, Vijayaraghavan K, Sivakumar B, Krishnaswamy K. Impact evaluation of iron and iodine fortified salt. J Med Res 1998; 108:203–11.
26. Ahmed F, Khan MR, Akhtaruzzaman M, Karim R, Marks GC, Banu CP, Nahar B, Williams G. Efficacy of twice-weekly multiple micronutrient supplementation for improving the hemoglobin and micronutrient status of anemic adolescent schoolgirls in Bangladesh. Am J Clin Nutr 2005;82:829–35.
27. Ahmed F, Khan MR, Jackson AA. Concomitant supplemental vitamin A enhances the response to weekly supplemental iron and folic acid in anemic teenagers in urban Bangladesh. Am J Clin Nutr 2001;74:108–15.
28. Soekarjo DD, de Pee S, Kusin JA, Schreurs WH, Schultink W, Muhilal, Bloem MW. Effectiveness of weekly vitamin A (10,000 IU) and iron (60 mg) supplementation for adolescent boys and girls through schools in rural and urban East Java, Indonesia. Eur J Clin Nutr 2004;58: 927–37.

Contribution of a novel high-density micronutrient condiment (HDMC) to nutrient adequacy of home-prepared Guatemalan dishes

Mónica Orozco, Noel W. Solomons, and André Briend

Abstract

Background. *The diet of low-income Guatemalan populations is mostly plant-based, deficient in some vitamins and minerals, and rich in antinutritional compounds that reduce the bioavailability of several micronutrients.*

Objective. *To describe the manner in which low-income Guatemalan women in rural and urban settings would prepare dishes for main meals using a high-density multimicronutrient condiment (HDMC) and to compare the nutrient density and contribution to the recommended dietary allowance (RDA) of the dishes with and without added HDMC.*

Methods. *A sample of 30 women, 15 each from rural and urban households, were enrolled. The women were given 20 g of the HDMC and asked to prepare a dish at home, serve it to their families at a time of their own choosing, record the recipe and the amount of condiment added, and report these facts to an interviewer on the following day. The nutrient content of each dish was calculated from food-composition table values for raw, whole ingredients and the package label values for the HDMC.*

Results. *For all dishes combined, the HDMC provided on average 78% of the total vitamins. The proportion of the total vitamins provided by the HDMC varied greatly among different dishes. Typically a single serving of a dish without added HDMC provided less than half of the RDA (vitamin B_{12} and folate) for children and adult women. The midday meal is the most important meal of the day and should provide at least half of the RDA of all essential nutrients. With the HDMC added, the dishes on average provided 2 to 10 times the RDA for nutrients such as vitamins B_6 and C and niacin in the reference children, and just satisfied the RDA intake for corresponding nutrients in adult women.*

Conclusions. *The proportion of the RDAs of micronutrients provided by this novel, micronutrient-rich condiment varies over a wide range, depending on idiosyncrasies of recipe ingredients, amounts of condiment added, individuals served, and age- and physiology-dependent requirements. HDMCs could provide an efficient way to deliver essential micronutrients to vulnerable populations.*

Key words: Fat-based condiments, Guatemala, high-density micronutrient condiments, micronutrients, recipe creation, supplements, vitamins

Introduction

The bases of the Guatemalan diet have been well studied [1]. The major staples are maize and legumes, complemented by other cereals, vegetables, and fruits and low amounts of animal products. This makes for a diet with low densities of some micronutrients and low bioavailability of others. As a result, the majority of the low-income members of Guatemalan society either consume or absorb insufficient amounts of vitamins and minerals to meet the reference norms for requirements and recommendations [2–4]. This is reflected in the prevalence of deficiencies of vitamin A [5], iron [6], zinc [7], and riboflavin [8], among other examples of micronutrient malnutrition.

The public health response to dietary micronutrient deficits has tended to deal individually with each specific nutrient, for example, by supplementation or fortification programs for vitamin A [9, 10] or iodization of salt [11]. To prevent iron deficiency and anemia prenatally, iron is combined with folic acid [12]. However, many have argued that approaches to micronutrient deficiency should simultaneously address a broad range of nutrients, not just one or two [13–16]. This

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principle is embodied in microencapsulated sprinkles [17] and foodlets* [18].

A fat-based condiment product developed initially for protein–energy malnutrition rehabilitation in famine situations [14, 218] has storage advantages in tropical countries [19]. In situations in which energy deficit is not a problem, the same basic formulation represents a promising vehicle to bring multiple micronutrients to individuals in the form of a condiment product similar to a bouillon cube. Bouillon cubes are widely used in cooking throughout the world. They are well adapted to cuisines based on soups, stews, and casseroles, which are basically solid food elements floating in a liquid stock.

The purpose of this study was to provide low-income women with the pilot version of this high-density multimicronutrient condiment (HDMC) and make standardized observations on how the product could be incorporated into common dishes for their households. Because the concentrations of the micronutrients in the condiment had been arbitrarily decided by the manufacturer, this study was conducted to explore how low-income women in this setting would use the condiment, in order to allow for further adjustments to the final formulation. We report the nature and diversity of the recipes that were created to use the HDMC, the amounts of the condiment used in various dishes, and the relative contribution of the intrinsic (food) and extrinsic (HDMC) micronutrients to the dishes and to micronutrient requirements.

Subjects and methods

Subjects

Thirty low-income women 18 to 50 years of age participated in this study; 15 of them were mothers of children attending one of three day-care centers in Guatemala City (urban setting), and the other 15 were mothers living in Buena Vista, Sacatepequez (rural setting). CeSSIAM´s Human Subjects Committee reviewed all ethical considerations and approved the study. Oral informed consent was obtained from prospective participants; more than 90% of those asked agreed to participate.

Methods

A preliminary trial was performed to determine what flavors of HDMC the mothers preferred. The tested flavors were couscous (a coarsely ground semolina pasta used as a staple in North African countries), beef, and chicken. Twenty-gram samples of the most preferred variety in the urban area (chicken flavor) and the rural area (couscous flavor) were distributed to the subjects, who were asked to prepare a recipe of their own creation using common ingredients. The products delivered were prototype formulations of highly nutrient-dense spreads (HNDS) (Nutriset, Malaunay, France), with a preliminary nutrient mixture formulation pending definitive composition of a final preparation. The vitamin contents per 100 g of product are shown in **table 1**.

The day after receiving the HDMC, the mothers were asked to recall how the recipe was prepared, the ingredients used, and which family members had consumed the dishes. Common measures, such as cups and tablespoons, were employed by the participants to quantify the ingredients used in the recipes. The participants were also requested to rate the organoleptic quality of their dishes by simply reporting whether they and their families liked or disliked the dishes. No additional data regarding other foods consumed during the same meal were collected.

Food-composition tables from INCAP (Instituto de Nutrición de Centroamérica y Panamá) [20] were used to determine the nutritional content of the raw and whole ingredients used in the recipes, and the values on the HDMC package label served to complete the nutritional information for the recipe. The values given throughout this paper are maximum values, since the expected losses from exposure to heat and other interactions in the foods are disregarded. The nutrient contents of each dish were computed and interpreted in terms of nutrient density, average individual intakes, and contribution to average individual RDA adequacy.

The significance of differences between groups was determined by the *t*-test; a *p* value less than .05 was considered to indicate statistical significance.

TABLE 1. Amounts of vitamins per 100 g of HDMC and per 20-g portion distributed to households

Vitamin	mg/100 g	mg/20 g
Vitamin A	20	4
Vitamin C	6,667	1,333.4
Vitamin B_1	53	10.6
Vitamin B_2	87	17.4
Vitamin B_6	87	17.4
Vitamin B_{12}	0.067	0.013
Folic acid	9.33	1.87
Niacin	1,000	200

HDMC, high-density micronutrient condiment

*The term “foodlet” is a generic denomination for a vehicle of multiple micronutrient supplementation in the form of a miniature food item or condiment (from “food” plus the French diminutive “let”). It was coined at an ad hoc meeting of researchers and public health professionals in Rio de Janeiro in 1999. The derivative “FOODlet” is used for spreads or Sprinkles forms, whereas “foodLET” refers to the form of a small chewable candy, incorporating the features of a tablet.

TABLE 2. Recipes from the rural and urban areas

Rural recipe				
R1 ½ lb noodles 5 tomatoes 1 onion 5 tbsp vegetable oil	R2 1 lb rice 1 small onion 3 tomatoes ½ lb green peas 1 carrot oil for frying	R3 ¼ lb noodles 3 tomatoes 1 small onion 3 sausages 2 small celery stems salt 1 tbsp water	R4 ½ lb chicken 1 tomato 1 small onion 1 carrot 1 potato ½ guisquil[a] 1 oz string beans salt	R5 ½ lb noodles 2 tomatoes 1 onion oil for frying salt
R6 ½ lb noodles 2 tomatoes 1 onion oil for frying salt	R7 2 eggs 1 onion 8 tomatoes oil for frying salt	R8 2 sausages 10 tomatoes 1 onion oil for frying	R9 1 chorizo ½ tomato ½ onion 2 cilantro stems bay leaves oil for frying salt	R10 1 guisquil 2 tomatoes 1 onion 1 carrot 2 big potatoes 2 lb rice 3 tbsp vegetable oil
R11 1 lb rice 2 tomatoes 1 onion 2 tbsp vegetable oil	R12 2½ lb chicken 4 tomatoes 2 slices onion 1 stem celery 3 guisquiles ½ lb noodles	R13 ½ lb noodles 3 tomatoes 1 slice onion 6 guisquiles	R14 2 lb chicken 10 tomatoes 1 onion 1 slice garlic 1 tbsp vegetable oil	R15 1½ lb chicken 3 tomatoes 1 onion 2 guisquiles ½ guicoy[c] ½ lb noodles

Urban recipes				
U1 ½ lb ground beef meat 2 guisquiles 6 carrots 1 small celery stem 1 green pepper salt to season oil for frying	U2 1 ½ lb chicken ½ lb rice 4 tomatoes 1 onion cilantro ½ tbsp minced garlic	U3 1 lb chicken ½ guisquil 2 carrots 1 tomato 1 onion cilantro	U4 4 oz chicken 4 oz noodles ½ onion ¼ guisquil ¼ carrot ¼ lb broccoli 1 tbsp soy sauce oil for frying	U5 1 lb spinach 2 eggs ½ onion 1 tomato 1 small garlic oil for frying
U6 8 tomatoes 1 onion 1 red pepper ½ tsp minced garlic 5 sausages 2 eggs butter ½ lb cheddar cheese	U7 6 pieces chicken 2 green peppers 1 onion ½ tbsp margarine 6 oz cream 1 tbsp mustard	U8 ½ lb noodles ½ onion 1 package tomato sauce 1 pinch salt to season	U9 2 tomatoes 1 onion 1 green pepper 1 potato 2 slices garlic 1 lb beef meat oil for frying (about 3 tbsp)	U10 1 tomato 1 carrot 1 small green pepper 2 potatoes 1 slice garlic 1 lb rice oil for frying (about 3 tbsp)
U11 1 lb macuy[b] 1 pinch salt	U12 2 tomatoes 4 celery stems 1 green pepper 1 onion 1 lb chicken ½ lb rice 1 pinch salt	U13 1 lb tomatoes 1 green pepper 1 onion 2 lb chicken 1 lb potatoes ½ tsp salt	U14 1 lb tomatoes 1 oz peppers 1 onion 2 lb red beans 1 lb fried pig skin 2 oz husk tomatoes 2 oz toasted pumpkin seeds oregano 1 tsp salt	U15 1 onion 1 can yellow corn 1 lb rice 1 pinch salt 4 tbsp vegetable oil

a. Guisquil: "Chayote," *Sechium edule* (Jacq.) Swartz.
b. Macuy: Herb *(Solanum americanum)*.
c. Guicoy: cucurbit similar to a pumpkin.

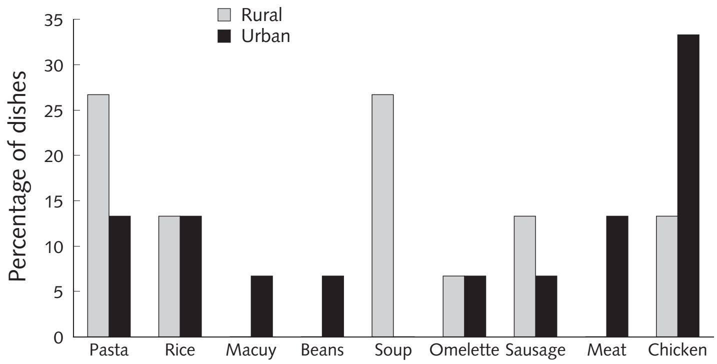

FIG. 1. Percentage of dishes prepared by urban (open bars) and rural (shaded bars) women according to category of recipe

Results

Household demographics

The number of persons consuming meals per household in the 30 families ranged from 2 to 11, with a median of 5 and a mode of 3. The median was 4 in urban households and 5 in rural households.

Characteristics of the recipes

The individual recipes from the 30 households are provided in **table 2.** Nine basic categories of dishes were created, as shown on the horizontal axis of **figure 1**. They are arranged from left to right from the most simple and plant-based to those based on animal products. The most popular items were chicken dishes, followed by pasta dishes, soups, and rice dishes. The distribution suggests a gradient from simpler dishes for rural families to more animal-based dishes for urban families.

The number of ingredients in the dishes ranged from one to nine, with a median number of five. The mean number of ingredients per dish was 6.1 ± 1.6 for urban recipes and 5.5 ± 1.2 for rural recipes (p = .52). The total energy of the dishes ranged from 161 to 4,699 kcal (mean, 1,608 ± 1,142; median, 1,629). The average energy per dish per consumer ranged from 26 to 1,566 kcal.

All of the participants from the rural and urban areas stated that they and their families liked the dishes prepared with the HDMC.

Distribution of the provision of micronutrients from food ingredients (intrinsic) and added HDMC (extrinsic)

Figure 2 shows the distribution of the amounts of HDMC added to the dishes. The median amount ranged from 10 to 14.9 g per dish. Rural mothers used more of the condiment than urban mothers: for the urban households the median ranged from 10 to 14.9 and for the rural group 20 g.

Table 3 shows the average contribution of the vitamins in the HDMC (extrinsic contribution) as a percentage of the total amount of vitamins in the dishes for the whole group and for urban and rural participants. The differences between these percentages and 100% represent the percentages of the amounts of

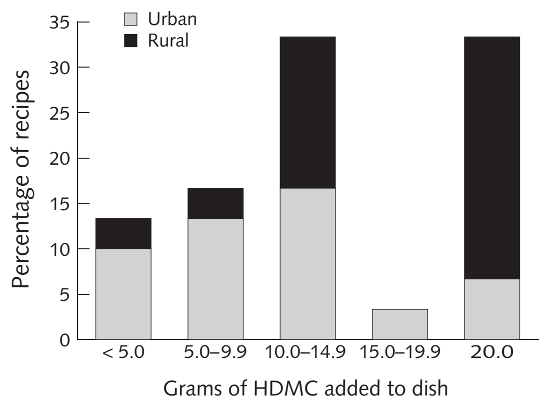

FIG. 2. Percentage of dishes prepared by urban (open bars) and rural (shaded bars) women according to amount of HDMC added

TABLE 3. Percentages of amounts of vitamins in dishes that were provided by the HDMC (mean ± SD)

Vitamin	All participants	Urban	Rural
Riboflavin	85 ± 13	79 ± 13	91 ± 11
Vitamin C	85 ± 14	81 ± 16	88 ± 11
Vitamin B_{12}	83 ± 22	77 ± 24	89 ± 18
Thiamine	81 ± 12	80 ± 12	82 ± 13
Niacin	77 ± 21	70 ± 20	83 ± 20
Vitamin B_6	73 ± 27	59 ± 27	87 ± 18
Folates	72 ± 20	70 ± 22	74 ± 19
Vitamin A	67 ± 32	78 ± 26	56 ± 35
All vitamins	78 ± 7	74 ± 7	81 ± 12

HDMC, high-density micronutrient condiment vitamins contributed by the food ingredients (intrinsic contribution). For the group as a whole, the percentage of vitamins contributed by the HDMC was highest for riboflavin and vitamin C, and the percentage contributed by the food ingredients was highest for vitamin A. For the urban group, the percentage contributed by the food ingredients was highest for vitamin B_6.

Table 4A gives the amount of each vitamin per dish, its density (the amount per 1,000 kcal), and the amount per individual serving for dishes prepared without added HDMC. Three of these dishes had no calculable amount of at least one of the vitamins of interest, and two others had no more that 0.5 mg of one of the vitamins of interest.

The amount of vitamin per dish varied greatly among the different dishes. The nutrient density of the dishes per 1,000 kcal ranged from 0.5 of the adult RDA for vitamin B_{12} to twice the adult RDA for vitamin A.

Table 4B gives the same statistics for dishes prepared with added HDMC. If we examine the differences between the lowest and the highest absolute amount of any of the nutrients in the spread as consumed by household members, we find that the greatest amount of vitamin B_{12} was 9 times greater than the least amount. At the other extreme, there was a 110-fold difference between the least amount of vitamin A derived by any participant from the HDMC in their meal and the greatest.

The increase in the quantities of nutrients per consumer ranged from 2- to 8-fold after the addition of HDMC, but the amounts consumed by individuals are hard to interpret in isolation. Hence, we have provided the descriptive statistics for what would be the contribution to the dietary reference intake (DRI)-RDA with respect to U.S. and Canadian norms [21] for 4- to 8-year old children, nonpregnant adult women, pregnant adult women, and lactating adult women. These assumptions (i.e., uniform portion size across generations and standard reference recipes from food composition tables) has several shortcomings, since portion sizes for these four groups will differ substantially, and members of different genders and age groups in a family would have different daily energy requirements or needs.

However, it is common opinion that servings of the midday meal are more equitable among family members than are those of the morning and late evening meals. Since we do not have empirical data on differences in the amounts of servings among the consumers, the simplest mathematical assumption is that of equal partition. **Tables 5A** and **5B** shows the percentages of the RDA adequacy of vitamins for the four groups supplied by the dishes prepared without and with added HDMC, respectively, on the assumption that each family member consumes the same amount of

TABLE 4. Amounts of vitamins in principal dishes prepared in rural and urban Guatemalan households (mean ± SD [range])[a]

A. Without added HDMC

Vitamin	Amount per dish	Density per 1,000 kcal	Amount per consumer
Vitamin A (RE)	1,358 ± 2,727 (6–14,062)	1,350 ± 2,500 (6 – 9,570)	375 ± 878 (1 – 4,685)
Vitamin C (mg)	114 ± 96 (4–416)	168 ± 374 (5–2,045)	32 ± 29 (1–104)
Thiamine (mg)	1.2 ± 0.9 (0.1–3.5)	1.1 ± 1.0 (0.2–4.4)	0.3 ± 0.3 (0.03– 1.2)
Riboflavin (mg)	1.4 ± 1.5 (0.2–8.6)	1.4 ± 1.8 (0.2–7.8)	0.4 ± 1.8 (0.02–2.9)
Niacin (mg)	30.2 ± 28.2 (1.6–100.3)	19.4 ± 10.6 (3.6–48.5)	8.2 ± 8.5 (0.4–33.4)
Vitamin B_6 (mg)	4.2 ± 5.7 (0–24.4)	3.0 ± 4.3 (0–18.0)	1.2 ± 1.8 (0–8.1)
Folates (μg)	463 ± 535 (0–1,874)	419 ± 657 (0–3,548)	139 ± 183 (0–625)
Vitamin B_{12} (μg)	1.6 ± 2.5 (0–12.5)	1.4 ± 1.9 (0–6.3)	0.4 ± 0.5 (0–2.5)

B. With added HDMC

Vitamin	Amount per dish	Density per 1,000 kcal	Amount per consumer
Vitamin A (RE)	3,583 ± 2,842 (444–16,062)	4,613 ± 5,034 (224–8,727)	1,000 ± 985 (89–5,359)
Vitamin C (mg)	896 ± 438 (36–1,638)	1,266 ± 157 (111–6,342)	240 ± 157 (39–681)
Thiamine (mg)	7.5 ± 3.7 (1.9–14.1)	9.9 ± 11.5 (0.9–48.8)	2.0 ± 1.4 (0.3–6.5)
Riboflavin (mg)	12.1 ± 5.6 (3.1–20.4)	16.0 ± 18.5 (1.45–80.1)	3.2 ± 2.0 (0.5–9.2)
Niacin (mg)	148 ± 65 (55–300)	185 ± 207 (24–903)	40 ± 24 (12–109)
Vitamin B_6 (mg)	14.8 ± 6.9 (5.3–33.1)	17.6 ± 17.9 (1.9–79.3)	4.0 ± 2.4 (0.9–11.0)
Folates (μg)	1,575 ± 868 (327–3,716)	1,974 ± 2,132 (154–8,976)	435 ± 326 (55–1,239)
Vitamin B_{12} (μg)	9.8 ± 4.3 (2.9–18.6)	12.7 ± 14.9 (1.1–65.9)	2.5 ± 1.4 (0.7–6.7)

HDMC, high-density micronutrient condiment

a. The values are maximum estimates, since it is assumed that there are no losses of nutrients from the ingredients or the HDMC during processing and preparation of the dishes.

TABLE 5. Percentage of RDAs of vitamins provided by principal dishes prepared in rural and urban Guatemalan households (mean ± SD [range])[a]

A. Without added HDMC

Vitamin	Children (4–8 yr)	Adult women	Pregnant women	Lactating women
Vitamin A (RE)	179 ± 415 (1–2,194)	102 ± 237 (0.4–1,254)	93 ± 216 (0.4–1,140)	55 ± 128 (0.2–675)
Vitamin C (mg)	127 ± 117 (4–416)	42 ± 39 (1.5–139)	37 ± 35 (1.3–122)	26 ± 24 (1 ± 87)
Thiamine (mg)	58 ± 51 (8–200)	32 ± 28 (5–109)	25 ± 22 (4–86)	25 ± 22 (4–86)
Riboflavin (mg)	69 ± 86 (5–480)	37 ± 47 (3–262)	29 ± 37 (2–206)	26 ± 32 (2–180)
Niacin (mg)	104 ± 105 (5–418)	59 ± 60 (3–239)	46 ± 47 (2–186)	49 ± 49 (2–197)
Vitamin B_6 (mg)	196 ± 293 (0–1358)	266 ± 163 (59–737)	62 ± 92 (0–429)	59 ± 88 (0–407)
Folates (μg)	72 ± 91 (0–312)	36 ± 45 (0–156)	24 ± 30 (0–104)	29 ± 36 (0–125)
Vitamin B_{12} (μg)	31 ± 44 (0–208)	15 ± 22 (0–104)	14 ± 20 (0–96)	13 ± 19 (0– 89)

B. With added HDMC

Vitamin	Children (4–8 yr)	Adult women	Pregnant women	Lactating women
Vitamin A (RE)	332 ± 430 (24–2,360)	190 ± 246 (14–1,349)	173 ± 223 (13–1,226)	102 ± 132 (7–726)
Vitamin C (mg)	960 ± 628 (158–2,723)	320 ± 209 (53–908)	282 ± 185 (46–801)	200 ± 131 (33 ± 567)
Thiamine (mg)	334 ± 232 (52–1,083)	182 ± 126 (28–591)	143 ± 99 (22–464)	143 ± 99 (22–464)
Riboflavin (mg)	536 ± 339 (86–1,540)	293 ± 185 (47–840)	230 ± 145 (37–660)	158 ± 97 (34–428)
Niacin (mg)	495 ± 305 (144–1,361)	283 ± 174 (82–778)	220 ± 136 (64– 605)	233 ± 144 (68–640)
Vitamin B_6 (mg)	664 ± 407 (148–1,842)	266 ± 163 (59–737)	210 ± 128 (47–582)	199 ± 122 (44–553)
Folates (μg)	217 ± 163 (27–619)	109 ± 82 (14–310)	73 ± 54 (9–206)	87 ± 65 (11–248)
Vitamin B_{12} (μg)	241 ± 204 (58–1,117)	120 ± 102 (29–558)	111 ± 94 (27–515)	103 ± 87 (25– 479)

HDMC, high-density micronutrient condiment

a. The values are maximum estimates, since it is assumed that there are no losses of nutrients from the ingredients or the HDMC during processing and preparation of the dishes.

food. On a daily basis, the child has the lowest requirement and the pregnant or lactating woman the highest, depending on the particular vitamin.

When the HDMC was added, lactating women obtained, on average, 99% of their RDA of vitamin A, but the percentage ranged from only 7% in one household to over 700% in another. This information is valuable to determine the range of exposure of the HDMC across the population in order to adjust the exposure of various nutrients to characterize the contribution or risk of excessive intake. We expect that the final formulation of the HDMC will contain lower concentrations of vitamin A than the prototype version used here. For this group of women, the RDA for vitamin B_{12} intake was just satisfied, on average, by the dishes prepared in individual households, which provided them with from one-quarter to almost five times the RDA from a serving of the HDMC-containing dish. Single servings of the meals with added HDMC would cover, on average, the daily requirements for the other micronutrients studied. A young schoolchild in the same household would exceed his or her RDA with a single serving from the average dish, with a 2.2-fold excess for folates and a 2.4-fold excess for vitamin A, to an almost 10-fold excess per typical serving for vitamin C and a more than 5-fold excess for riboflavin and vitamin B_6.

Discussion

Food-based supplementation strategies represent a new option for fighting micronutrient deficiencies in underdeveloped countries. The idea arose out of a search for efficient and sustainable solutions to food shortages in vulnerable populations, and the highly nutrient-dense spreads (HNDS) were designed as an alternative to traditional supplements used in these situations [18]. We and others have adapted a sweet spread, but the emphasis is not on energy and protein but rather on vitamin and mineral sufficiency. The use of fortified spreads for this purpose was pioneered by Lopriore and Branca [19] for iron deficiency, and the high-density multimicronutrient condiment (HDMC) used in this study has evolved from an HNDS.

Several factors have to be taken into consideration when designing strategies for these populations. Palatability has become an important factor for the success of a home fortification program. In this study, the palatability of dishes prepared with the HDMC was assessed by questioning the women who prepared the dishes for their families. This study also aimed to determine the ways these new elements could be used in the traditional cuisine of low-income Guatemalans. Food-composition tables allowed determination of the nutritional contribution of the ingredients of the dishes and the improvement of their nutritional quality with the addition of the HDMC. The use of food-composition tables to estimate the amounts of micronutrients in diets and specific foods has well-recognized shortcomings. Direct chemical analysis of composite samples would be the gold-standard method; however, the resources available and the need for rapid screening made the use of food-composition tables the best option.

Some assumptions were made in order to calculate the nutritional content of the recipes and the individual consumption of micronutrients. The nutritional content of the dishes was determined on the basis of raw ingredients, without consideration of the losses due to heating during cooking. This method overestimates the content of labile vitamins in the dishes and represents one of the major weaknesses of the study. To calculate the quantity of micronutrients consumed per person, we divided the quantity of micronutrients in the dish by the number of family members, on the assumption that everyone ate the same amount and that there were no leftovers. This method can overestimate or underestimate individual micronutrient intakes.

The diet of the average Guatemalan consists of three main meals and a series of snacks. Breakfast and supper are primarily grain-based and consist of tortillas or bread, beans, and a beverage (coffee or gruel). Eggs and fruits such as bananas or plantains (hard, starchy bananas used for cooking, which are a staple food in tropical regions) are also part of the “bookend” meals, equivalent meals on either side of the main midday meal. Traditionally in Guatemala, lunch is the most varied meal of the day, with a main dish accompanied by a beverage (such as a fruit drink or coffee), tortillas, and often a fresh fruit or sweet for dessert. In terms of the energy contribution from main meals, we based our distribution model on the generally accepted view that in Guatemala the midday meal supplies about 50% of daily energy [1, 22]. This rule could also be applied to the micronutrient content of foods. According to our results, in some cases the intrinsic ingredients of the recipes could not provide 50% of the RDAs of folic acid, thiamine, riboflavin, and vitamin B_{12} for lactating or pregnant women. However, given the low nutrient density and bioavailability of some micronutrients in the maize- and legume-based morning and evening meals of low-income Guatemalans [23, 24], there is a demand on the midday main meal to supply on average considerably more than 50% of the RDAs of the micronutrients. The addition of the HDMC considerably increased the nutritional contents of the dishes.

In the life-cycle approach taken in **table 5**, we are confronted with the biological reality of the great diversity, within the same household, of nutrient recommendations for members of different generations. If a typical individual portion from an HDMC-enriched household dish met the needs of a pregnant or lactating woman, it would not be unreasonable to assume that a schoolchild would receive an excess of some nutrients, such as vitamin A, from the same portion. With the observed use of the condiment in our study homes, the average intake of vitamin A for a 4- to 8-year-old child consuming a typical portion of the main meal dish with added HDMC would be 2.2 to 9.6 times the basic need, and in some households the intake would be 20 or more times the quantity needed. Little concern arises from excessive intake of the added water-soluble vitamins, but vitamin A represents a special case. Alternatively, the use of provitamin A carotenoids, such as β-carotene, which would be compatible with the fat-based HDMC, might mitigate any risk of hypervitaminosis A. Therefore, although we still look for ways to support the needs of pregnant and lactating women, the use of HDMC could carry the risk of producing chronic excessive intakes of some nutrients because of the possibility that a consumer could consistently and frequently add large amounts of the condiment to household dishes.

We see marked contrasts across the generations. On average, one serving of a dish without added HDMC would satisfy 100% of a child's RDAs for vitamin C, niacin, vitamin B_6, and vitamin A, whereas none of the requirements for adult women in any physiological state would be satisfied by one serving of a dish alone. Even when HDMC was added, pregnant and lactating women on average did not obtain their RDA of folates.

The use of HDMC in the studied group needs further exploration. It will be necessary in the future to adjust the micronutrient composition according to local needs and adapt it to the culinary realities in different cultural settings. Although the recipes were very well accepted by all of the participant mothers, a Guatemalan flavor, such as that of the local chicken- and beef-flavored powdered bouillon, might enhance the overall acceptability of the supplement. HDMCs could provide an efficient way to deliver essential micronutrients to vulnerable populations; their apparent versatility provides additional value to this new possibility of fighting micronutrient deficiencies in the world.

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References

1. Mata LS. The children of Santa María Cauqué. Cambridge, Mass, USA: MIT Press, 1978.
2. Gamero H, Arita M, Bulux J, Solomons NW. Dietary pattern and nutrient intake in preschool children from three rural villages in the Province of Santa Rosa, Guatemala [in Spanish]. Arch Latinoam Nutr 1996;46:22–26.
3. Solomons NW. Micronutrients and urban life-style: lessons from Guatemala. Arch Latinoam Nutr 1997;47(2 suppl 1):44–9.
4. Lutter CK, Rivera JA. Nutritional status of infants and young children and characteristics of their diets. J Nutr 2003;133:2941S–9S.
5. Romero-Abal ME, Mendoza I, Bulux J, Solomons NW. Blood retinol and beta-carotene levels in rural Guatemalan preschool children. Eur J Epidemiol 1995;11:133–9.
6. Dewey KG, Romero-Abal ME, Quan de Serrano J, Bulux J, Peerson JM, Eagle P, Solomons NW. Effects of discontinuing coffee intake on iron status of iron-deficient Guatemalan toddlers: a randomized intervention study. Am J Clin Nutr 1997;66:168–76.
7. Rivera JA, Ruel MT, Santizo MC, Lonnerdal B, Brown KH. Zinc supplementation improves the growth of stunted rural Guatemalan infants. J Nutr 1998;128:556–62.
8. Boisvert WA, Castaneda C, Mendoza I, Langeloh G, Solomons NW, Gershoff SN, Russell RM. Prevalence of riboflavin deficiency among Guatemalan elderly people and its relationship to milk intake. Am J Clin Nutr 1993;58:85–90.
9. West KP Jr, Howard GR, Sommer A. Vitamin A and infection: public health implications. Annu Rev Nutr 1989;9:63–86.
10. Dary O, Mora JO, International Vitamin A Consultative Group. Food fortification to reduce vitamin A deficiency: International Vitamin A Consultative Group recommendations. J Nutr 2002;132(9 suppl):2927S–2933S.
11. Jooste PL, Weight MJ, Lombard CJ. Short-term effectiveness of mandatory iodization of table salt, at an elevated iodine concentration, on the iodine and goiter status of schoolchildren with endemic goiter. Am J Clin Nutr 2000;71:75–80.
12. Stoltzfus R, Dreyfuss M. Guidelines for the use of iron supplements to prevent and treat iron deficiency anemia. Washington, DC: ILSI Press, 1998.
13. Huffman SL, Baker J, Shumann J, Sehner ER. The case for promoting multiple vitamin and mineral supplements for women of reproductive age in developing countries. Food Nutr Bull 1999;20:379–94.
14. Briend A. Highly nutrient-dense spreads: a new approach to delivering multiple micronutrients to high-risk groups. Br J Nutr 2001;85(suppl 2):S175–S179.
15. Nestel P, Briend A, de Benoist B, Decker E, Ferguson E, Fontaine O, Micardi A, Nalubola R. Complementary food supplements to achieve micronutrient adequacy for infants and young children. J Pediatr Gastroenterol Nutr 2003;36:316–28.
16. Christofides A, Schauer C, Sharieff W, Zlotkin SH. Acceptability of micronutrient sprinkles: a new food-based approach for delivering iron to First Nations and Inuit children in Northern Canada. Chronic Dis Can 2005;26:114–20.
17. Smuts CM, Lombard CJ, Benade AJ, Dhansay MA, Berger J, Hop le T, Lopez de Romana G, Untoro J, Karyadi E, Erhardt J, Gross R; International Research on Infant Supplementation (IRIS) Study Group. Efficacy of a foodlet-based multiple micronutrient supplement for preventing growth faltering, anemia, and micronutrient deficiency of infants: the four country IRIS trial pooled data analysis. J Nutr 2005;135:631S–638S.
18. Briend A, Lacsala R, Prudhon C, Mounier B, Grellety Y, Golden MH. Ready-to-use therapeutic food for treatment of marasmus. Lancet 1999;353(9166):1767–8.
19. Lopriore C, Branca F. Strategies to fight anaemia and growth retardation in Saharawi refugee children. Rome: European Commission Humanitarian Office (ECHO), Comitato Internazionale per lo Sviluppo dei Popoli (CISP), Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione (INRAN), 2001.
20. Menchú MT, Méndez H, Lemus J. Tabla de composición de alimentos de Centroamérica. Guatemala City, Guatemala: Institute of Nutrition for Central America and Panama, Organización Panamericana de la Salud (OPS), 2000.

21. Institute of Medicine. Food and Nutrition Board. Dietary reference intakes, vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press, 2001.
22. Mendoza I, Saenz de Tejada E, Sanchez ME, Solomons NW. Dietary pattern of preschool children during diarrhea in a coffee-growing area of rural Guatemala. Ecol Food Nutr 1996;35:25–41.
23. Solomons NW, Jacob RA, Pineda O, Viteri FE. Studies on the bioavailability of zinc in man. Effects of the Guatemalan rural diet and of the iron-fortifying agent NaFeEDTA. J Nutr 1979;109:1519–1528.
24. Krause V, Solomons NW, Tucker KL, Lopez CY, Ruz M, Kuhnlein KV. Rural-urban variation in the calcium, iron, zinc and copper content of tortilla and intake of these minerals from tortilla by women in Guatemala. Ecol Food Nutr 1992;28:289–97.

Effectiveness of intermittent iron treatment of two- to six-year-old Jordanian children with iron-deficiency anemia

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Abstract

Background. *Iron deficiency is a common nutritional problem in young children among vulnerable populations in Jordan. Several studies have shown the effectiveness of intermittent iron supplementation in improving iron status. Such a study has not been carried out in 2- to-6-year-old Jordanian children diagnosed with iron deficiency anemia in a clinical setting.*

Objective. *To study the effectiveness of intermittent versus daily iron treatment in a clinical setting in 2- to 6-year-old Jordanian children with iron-deficiency anemia.*

Methods. *About 4,400 children aged 2 to 6 years who visited Prince Hashim Military Hospital in Zarqa, Jordan, from August 2000 to June 2001 were screened for age, general health, and birthweight. About 10% of these children were screened for anemia, using complete blood count (defined as a hemoglobin level ≤ 10.5 g/dL, and a mean corpuscular volume ≤ 75 fL). Anemic children underwent further screening for iron deficiency, defined as serum ferritin level ≤ 12 μg/L. Children with iron-deficiency anemia, as indicated by hemoglobin ≤ 10.5 g/dL, mean corpuscular volume ≤ 75 fL, and serum ferritin ≤ 12 μg/L, or as indicated by mean corpuscular volume ≤ 75 fL and hemoglobin ≤ 10.5 g/dL, were enrolled in the study after informed oral consent by their parents. Study children (n = 134) were assigned randomly to one of three groups. Subjects in group 1 (n = 45), group 2 (n = 45), and group 3 (n = 44) received iron treatment daily, weekly, and twice weekly, respectively. Out of 134 children recruited for the study, only 63 (39 boys and 24 girls) completed the 3-month treatment period. All of the children received medicinal iron drops at a dosage of 5 mg elemental iron as ferrous sulfate per kilogram of body weight. The parents also received nutritional counseling.*

Results. *At the end of treatment, hemoglobin, serum ferritin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration increased significantly in all groups with no significant differences between groups. The increases in hemoglobin in groups 1, 2, and 3 were 2.47 ± 0.17, 2.12 ± 0.18, and 2.18 ± 0.18 g/dL, respectively. Measurements of final serum ferritin concentration were available for only 12, 12, and 10 children in groups 1, 2, and 3, respectively. In all children who completed the study, except for one in group 1, hemoglobin, mean corpuscular volume, and serum ferritin reached normal values in response to iron treatment.*

Conclusions. *Weekly and twice-weekly iron therapy with 5 mg elemental iron as ferrous sulfate per kilogram of body weight accompanied by nutritional counseling was as effective as daily iron therapy in correcting iron-deficiency anemia in 2- to 6-year-old children under the clinical conditions of this study.*

Key words: clinical setting, intermittent, intermittent iron treatment, iron-deficiency anemia, young children

Introduction

Iron deficiency is the most common single nutrient deficiency worldwide, with at least one billion people estimated to be iron deficient [1]. The more severe form of iron deficiency is iron-deficiency anemia, which is highly prevalent in developing countries [2]. The estimated prevalence of iron deficiency is 40% to 60% in developing countries among children between the ages of 6 months and 2 years, a period during which lack of iron can cause impairment in mental

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development [3]. The groups most vulnerable to and at risk of developing iron-deficiency anemia are infants and young children, pregnant women, and women of childbearing age [4, 5].

Iron has diverse biological functions, and it is this diversity that accounts for the wide-ranging consequences of its deficiency. The consequences of iron deficiency are serious and range from reduced work capacity [6, 7] and poor pregnancy outcome [4] in adults to impaired mental and motor development [8–10], impaired cognitive function [11, 12], behavioral abnormalities [8], poor learning achievement [13–16], and decreased growth rate [17, 18] in children. Scrimshaw [5] reviewed the effects of iron-deficiency anemia on infants and children and concluded that it retards their psychomotor development and impairs their cognitive performance. These adverse effects of iron-deficiency anemia have been also assessed in two recent studies by Walter [8, 9].

Long-term impairment due to iron-deficiency anemia has been observed in follow-up studies of children at 5 and 10 years of age [19, 20]. In addition, diminished levels of iron in both adults and children result in increased susceptibility to infection [7, 21]. Thus prevention and treatment of iron-deficiency anemia are especially important for infants and young children because of the adverse consequences associated with the condition and the fact that some of these consequences may be irreversible.

Jordan and many other countries distribute therapeutic iron supplements to pregnant women through the primary health care system in order to combat iron-deficiency anemia. Yet despite such large-scale programs, the prevalence of iron-deficiency anemia remains high worldwide [22]. In Jordan in 2002, the national prevalence rates of anemia, iron deficiency, and iron-deficiency anemia among women of reproductive age were 32%, 41%, and 22%, respectively [23]. Similar programs to combat IDA do not exist for young children who usually are treated based on the diagnosis of anemia in a clinical setting [24].

In Jordan, malaria, hookworm, and schistosoma do not constitute a problem. In a 1994 national study of intestinal parasites in Jordanian schoolchildren aged 8 to 11 years [25], the prevalences of *Entamoeba coli*, giardia, ascaris, and *Hymenolepis nana* were 14.3%, 8.4%, 1.5%, and 1.9%, respectively. These parasites were not found to be related to anemia.

In general, iron-supplementation programs are largely ineffective for a variety of reasons, the most important of which are insufficient supplies of iron supplements, low coverage of target populations, and low compliance with intake of supplements. Poor compliance is influenced by the undesirable side effects of iron supplements, which are related to the amount and form of the supplementary iron [24].

Iron therapy has proven to be a useful means of improving the iron status of iron-deficient individuals. A new strategy of iron therapy under study is intermittent iron supplementation, which has gained much attention over recent years because of its advantages over daily iron supplementation [2]. The rationale behind intermittent iron supplementation is that daily iron intake reduces the intestinal absorption of dietary iron and supplementary iron [26]. Intermittent iron supplementation is based on the concept of mucosal blockage of iron absorption, which argues that more efficient iron absorption occurs when the administration of iron is matched with the renewal of intestinal mucosal cells, which occurs roughly every 5 to 7 days [2, 25, 27]. Studies in rats [26, 28], young children [24, 29–31], adolescents [32], pregnant women [22], and nonpregnant women [33] have shown that the effectiveness of intermittent iron supplementation in improving iron status is similar to that of daily iron supplementation.

The aim of this study was to determine the effectiveness of weekly and twice-weekly iron treatment versus daily iron treatment in correcting iron-deficiency anemia in 2- to 6-year-old Jordanian children in a clinical setting.

Methods

Subjects

The study was carried out at Prince Hashim Military Hospital of the Royal Medical Services in Zarqa, Jordan. The study protocol was approved by the research committee of the Royal Medical Services. The study lasted for 11 months, from August 2000 through June 2001 [34]. The Zarqa district has a substantial proportion of low-income families. The clinic is located on the hospital grounds and is open to children up to 14 years of age from families affiliated with the army who are not medically insured and have generally low incomes.

In a study conducted at Prince Hashim Military Hospital in Zarqa from February 2001 through February 2002 [35], the reported monthly income of approximately 90% of the participating families ranged from US$140 to US$280. Approximately 40% of the study families lived below the poverty line, estimated by the Ministry of Social Development at US$37 per person per month [36].

The study subjects were selected from about 4,400 children aged 2 to 6 years who visited the hospital. The selection criteria for the study included that the child must have been born at full term with a birthweight ≥ 2.5 kg and exhibited normal growth with no signs of thalassemia, chronic illness, congenital anomalies, or chronic and repeated infections. Approximately 10% of these children met the selection criteria and therefore underwent complete blood count (CBC) screening as determined necessary by the resident physician or at the request of the parent. Based on CBC screening, only anemic children with hemoglobin ≤ 10.5 g/dL and mean corpuscular volume ≤ 75 fL were recruited to the study and only after oral informed consent was received from either of their parents. Serum ferritin was planned to be measured for all recruited children, but due to problems with supplies was determined for only 34 children. Serum ferritin values ≤ 12 μg/L were considered the cutoff point for iron deficiency [37, 38].

The diagnosis of iron-deficiency anemia was based on combined cutoff points of hemoglobin ≤ 10.5 g/dL, mean corpuscular volume ≤ 75 fL, and serum ferritin ≤ 12 μg/L, or based on combined cutoff points of hemoglobin ≤ 10.5 g/dL and a mean corpuscular volume ≤ 75 fL. According to Gibson [39], "A low MCV is a relatively specific index for iron deficiency anemia provided that the anemias of infection, chronic inflammatory disease, thalassemia minor, and lead poisoning have been excluded." These exclusion conditions were satisfied in our study subjects. Only patients diagnosed with iron-deficiency anemia were enrolled in the study. This screening method allowed us, within the constraints of the study, to have complete coverage of the targeted population rather than drawing a sample, which was not feasible under the conditions of this clinical study. To avoid bias, each study patient was allocated randomly to one of three groups according to a table of random digits. Initially, 134 study subjects were assigned randomly into one of three groups: group 1 (n = 45) received a daily dose of 5 mg of elemental iron per kilogram of body weight; group 2 (n = 45) received a weekly dose of 5 mg of elemental iron per kilogram of body weight on Fridays; group 3 (n = 44) received a twice-weekly dose of 5 mg of elemental iron per kilogram of body weight on Friday and Monday. Friday was designated as the day for receiving the weekly dose in order to help families remember to administer the medicine, since Friday is the Moslem day of rest. The final sample size was 21 for each study group.

Medical examination

Before enrollment in the study, all children were examined by the resident pediatrician at the clinic to ensure that every child recruited with low hematologic indices was otherwise in good health. If a child was of the appropriate age for the study and had low hemoglobin and mean corpuscular volume but was diagnosed with respiratory infection or other minor infection, the parents were asked to bring the child back to the clinic after the child was fully recovered to be treated for iron-deficiency anemia and possibly to be recruited into the study.

Anthropometric measurements

The weight and height of each child were measured on the day of enrollment in the study and, for those who completed the study, at the end of the 3-month treatment period. The children were weighed to the nearest 0.5 kg on a spring balance scale without shoes and wearing minimal clothing. Height was measured to the nearest 0.1 cm with a movable measuring rod attached to a platform scale while the child was standing up straight and looking forward with feet together.

Hematologic measurements

Children with hemoglobin ≤ 10.5 g/dL received a diagnosis of anemia. Those with hemoglobin ≤ 10.5 g/dL, mean corpuscular volume ≤ 75 fL, and serum ferritin ≤ 12 μg/L were diagnosed with iron-deficiency anemia. To perform a complete blood count, a blood sample of about 2 to 3 mL was drawn from the forearm by venipuncture by a trained nurse using a size 22 (¾″) syringe suitable for young children. The blood sample was transferred into a sterile vacuum tube containing K_3EDTA, to prevent coagulation. It was analyzed by an electronic counter (Sysmex K 1000, Tokyo, Japan). For serum ferritin, another blood sample of the same size was drawn and transferred into a vacutainer (Becton Dickinson, Franklin Lakes, NJ, USA) containing silicon gel to accelerate precipitation. The sample was then centrifuged to obtain the serum, which was kept frozen at –29°C until it was analyzed by a commercial chemiluminescence kit (IMMULITE, Diagnostic Products Corporation, Los Angeles, CA, USA). Hematologic measurements were also performed after 3 months of iron therapy.

Iron therapy

Therapeutic medicinal iron providing 5 mg of elemental iron per kilogram of body weight was administered as ferrous sulfate solution (Fer-In-Sol, Mead Johnson; Bristol-Meyers Squibb Egypt, Cairo). It was supplied with a dropper that was initially marked at 0.6 mL and 1 mL. Each mL provides 25 mg elemental iron. The dropper was marked further to enable the parents to administer the required dose. The dose was calculated according to the child's initial weight and was administered by either of the parents. The parents were instructed how to give and to administer the supplement in two equal portions half an hour to one hour before breakfast and dinner. This was done because nonheme iron supplements such as ferrous sulfate have a higher absorption rate on an empty stomach [40]; the rate can be as high as 50% in subjects with severe iron-deficiency anemia [41]. The parents were advised to mix the supplement with water, orange juice, or lemonade if the child refused to take the supplement on an empty stomach. The importance of compliance with the iron regimen was stressed, especially for the weekly and twice-weekly regimens. All of the families received checkup visits every two weeks during which the parents were encouraged to comply with the regimen and any questions that arose about the child's health and the foods eaten by the child were answered. Dietary iron intake was not assessed.

Nutritional counseling

The children were taken to the clinic by one or both parents. The parents were informed about the nutritional causes of iron-deficiency anemia, the consequences of the condition if left untreated, and the importance of compliance. The parents were also given nutritional guidance about iron-rich foods and about the enhancers and inhibitors of iron absorption. Nutritional guidance was also provided at the home checkup visits.

A brief account of the eating patterns of Jordanian toddlers was given by Faqih and Qazaq [42], but there are no recent data for Jordanian children 2 to 6 years of age. However, it is almost certain that these children of low-income families ate the family diet. The diet is based mainly on wheat bread, rice, sugar, milk and milk products (yogurt, labneh [concentrated yogurt], and cheeses), chickpeas, horse beans, and eggs, all of which are foods of low iron content and bioavailability. Iron in eggs has low bioavailability and reduces the bioavailability of nonheme iron [43]. Bread and other bakery products such as biscuits are often soaked in tea, which decreases iron bioavailability. Fortification of flour with iron and folic acid started in April 2002. Meat, poultry, and fish, the best food sources of highly bioavailable iron, are not within the financial reach of families of low economic status.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) by the general linear model procedures of the statistical analysis system (SAS Institute SAS/STAT, User`s Guide: Statistics. Release 6.04. SAS Institute, Cary, NC, USA). The child's age and sex and the initial values of each variable were analyzed as covariance. Correlation coefficients were calculated to assess the relationships between the initial and final values of each variable. Unless stated otherwise, $p \leq .05$ was considered to indicate statistical significance.

Results

Selected characteristics of the 63 children who completed the 3 months of treatment are shown in **table 1**. There were no significant differences among the three groups in age, sex ratio, weight, or height. At the end of the study, groups 1, 2, and 3 had 13 boys and 8 girls, 12 boys and 9 girls, and 14 boys and 7 girls, respectively. Of the 134 children who were recruited, 71 did not complete the study: 24 children in each of groups 1 and 2 and 23 children in group 3. Children failed to complete the study because they refused to take the medicinal iron, their parents did not administer their iron for the full 3 months, or their parents did not return with them to the clinic.

The average weights and heights of the children in all three groups increased significantly by the end of the study, as was expected in these young children (**table 1**). The average increases in height (1.8 cm) and weight (1.2 kg) are in line with the average increments in height and weight in healthy children of normal growth. There were no significant differences among the three treatment groups in the increases in height

TABLE 1. Anthropometric measurements of children before and after 3 months of iron treatment (mean ± SE [range])[a]

Measurement	Group 1 (13M, 8F)	Group 2 (12M, 9F)	Group 3 (14M, 7F)
Baseline			
Age—mo	44.6 ± 3.9 (24–77)	41.5 ± 5.7 (24–70)	43.5 ± 2.8 (24–70)
Height—cm	96.0 ± 2.3^{b} (81.5–122)	95.1 ± 1.9^{b} (82–116)	96.0 ± 2.1^{b} (82–115)
Weight—kg	14.6 ± 0.1^{d} (10.5–26)	15.0 ± 0.7^{d} (10.0–25)	14.5 ± 0.6^{d} (11.0–20)
3 mo			
Height—cm	97.8 ± 2.4^{c} (82.5–124)	96.4 ± 1.9^{c} (84–118)	97.7 ± 2.0^{c} (83–117)
Weight—kg	15.8 ± 0.7^{e} (11.5–27)	16.3 ± 0.7^{e} (12.0–27)	15.6 ± 0.6^{e} (11.5–21)

a. Groups 1, 2, and 3 received iron treatment daily, weekly, and twice weekly, respectively.
b, c. Mean heights within the same column with different superscripts are significantly different ($p < .05$).
d, e. Mean weights within the same column with different superscripts are significantly different ($p < .05$).

TABLE 2. Hemoglobin values (g/dL) in children before and after 3 months of iron treatment (mean ± SE)[a]

Measurement	Group 1 (13M, 8F)	Group 2 (12M, 9F)	Group 3 (14M, 7F)
Baseline	$9.54 \pm 0.16^{c,d}$	$10.10 \pm 0.17^{b,d}$	$9.98 \pm 0.17^{b,c,d}$
3 mo	$12.01 \pm 0.11^{b,e}$	$12.22 \pm 0.12^{b,e}$	$12.16 \pm 0.12^{b,e}$
Change	2.47 ± 0.17^{b}	2.12 ± 0.18^{b}	2.18 ± 0.18^{b}

a. Groups 1, 2, and 3 received iron treatment daily, weekly, and twice weekly, respectively.
b, c. Means within the same row with different superscripts are significantly different ($p < .05$).
d, e. Means within the same column with different superscripts are significantly different ($p < .05$).

or weight. There were no significant effects of the children's sex or age on treatment response, and therefore these factors were excluded from further analysis.

At baseline the mean hemoglobin was higher in group 2 than in group 1 (10.10 ± 0.17 vs. 9.54 ± 0.16 g/dL) (**table 2**). At the end of the 3-month treatment period, hemoglobin levels had increased significantly in all three treatment groups. There were no significant differences among the three groups in the final hemoglobin levels or in the increases in hemoglobin levels. Furthermore, when the initial hemoglobin levels were controlled for by covariance analysis, the three iron treatment regimens had the same effect on hemoglobin levels. All subjects in the three treatment groups showed a positive hemoglobin response to iron therapy, defined as a minimum increase of 1 g/dL in hemoglobin concentration [44]. The results of this study are in full agreement with those of another similar study that was carried out in the same hospital on 8- to 24-month-old Jordanian children diagnosed with iron-deficiency anemia. The daily iron dose (5 mg of ferrous sulfate solution per kilogram of body weight) was as effective as the twice-weekly dose [45].

The analysis of variance also showed that the lower the initial hemoglobin concentration, the greater the change in hemoglobin within individuals, regardless of treatment. This means that the greatest change in hemoglobin concentration occurred among the most anemic children.

TABLE 3. Hematologic values in children before and after 3 months of iron treatment (mean ± SE)[a]

Measurement	Group 1 (13M, 8F)	Group 2 (12M, 9F)	Group 3 (14M, 7F)
Baseline			
Hematocrit (%)	30.02 ± 0.46^c	31.44 ± 0.48^b	$31.26 \pm 0.48^{b,c}$
MCV (fL)	67.33 ± 1.31^b	69.95 ± 1.37^b	68.70 ± 1.37^b
MCH (pg)	21.82 ± 0.63^b	22.60 ± 0.66^b	22.30 ± 0.66^b
MCHC (g/dL)	31.85 ± 0.40^b	32.24 ± 0.42^b	32.18 ± 0.42^b
3 mo			
Hematocrit (%)	36.42 ± 0.30^b	36.94 ± 0.31^b	36.94 ± 0.31^b
MCV (fL)	79.50 ± 0.73^b	79.40 ± 0.77^b	78.8 ± 0.77^b
MCH (pg)	26.30 ± 0.41^b	26.76 ± 0.43^b	25.93 ± 0.43^b
MCHC (g/dL)	32.97 ± 0.17^b	33.09 ± 0.18^b	32.91 ± 0.18^b
Change			
Hematocrit (%)	6.40 ± 0.48^b	5.50 ± 0.50^b	5.69 ± 0.50^b
MCV (fL)	12.06 ± 1.26^b	9.45 ± 1.32^b	10.09 ± 1.32^b
MCH (pg)	4.48 ± 0.62^b	4.16 ± 0.65^b	3.63 ± 0.65^b
MCHC (g/dL)	1.12 ± 0.36^b	0.85 ± 0.38^b	0.74 ± 0.38^b

MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration

a. Groups 1, 2, and 3 received iron treatment daily, weekly, and twice weekly, respectively.

b, c. Means within the same row with different superscripts are significantly different ($p < .05$).

These results indicate that there is no difference between the effects of daily, weekly, and twice-weekly treatment on iron status and therefore on the correction of anemia in young children.

Table 3 shows the values for hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration before and after 3 months of iron treatment for the three treatment groups. The initial hematocrit values differed among the three groups in the same manner as did the hemoglobin levels: the hematocrit in group 1 was significantly lower than that in group 2 but not lower than that in group 3, and there was no significant difference in hematocrit between groups 2 and 3. Hematocrit increased significantly at the end of treatment in all three groups. There were no significant differences among the three groups in final hematocrit values or in the change in hematocrit, which averaged 5.9%.

The initial values of mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration were 68.6 fL, 22.2 pg, and 32.0 g/dL, respectively. There were no significant differences among the groups in these initial values. After 3 months of treatment, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration increased significantly by an average of 10.5 fL, 4.1 pg, and 0.9 g/dL, respectively. There were no significant differences among the three treatment groups in the increases in mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration (**table 3**).

Initial and final serum ferritin values were available for only 34 children: 12 children in each of groups 1 and 2 and 10 children in group 3 (**table 4**). The initial serum ferritin concentration was significantly lower in group 2 (6.58 µg/L) than in groups 1 (9.28 µg/L) and 3 (10.32 µg/L). There was no significant difference between the initial serum ferritin concentrations of groups 1 and 3. All dietary regimens led to a significant increase in serum ferritin, with no significant differences in final serum ferritin values among the three treatment groups. When initial serum ferritin concentration was controlled for by covariance analysis,

TABLE 4. Serum ferritin values (µg/L) in children before and after 3 months of iron treatment (mean ± SE)[a]

Measurement	Group 1 ($n = 12$)	Group 2 ($n = 12$)	Group 3 ($n = 10$)
Baseline	$9.28 \pm 0.64^{b,d}$	$6.58 \pm 0.64^{c,d}$	$10.32 \pm 0.71^{b,d}$
3 mo	50.17 ± 4.08^b	$47.43 \pm 4.08^{b,e}$	$46.70 \pm 4.47^{b,e}$
Change	40.88 ± 4.16^b	40.85 ± 4.16^b	36.38 ± 4.56^b

a. Groups 1, 2, and 3 received iron treatment daily, weekly, and twice weekly, respectively.

b, c. Means within the same row with different superscripts are significantly different ($p < .05$).

d, e. Means within the same column with different superscripts are significantly different ($p < .05$).

all three iron treatment regimens had the same effect on serum ferritin (average increase, 39.3 μg/L). Serum ferritin reflects iron stores in the body, and thus similar increases in serum ferritin reflect a similar improvement in iron status and correction of iron deficiency, and consequently correction of iron-deficiency anemia. However, this finding applies unequivocally only to the 34 children for whom final serum ferritin was analyzed. We discuss below the question of whether iron-deficiency anemia was corrected in all study children by considering the fact that study children were diagnosed initially as having iron-deficiency anemia based on the combined criteria of low indicators of hemoglobin, mean corpuscular volume, and serum ferritin.

Discussion

The increases in hemoglobin levels observed in the present study as a result of intermittent iron treatment are either lower or higher than those found in previous studies. A 3-month therapeutic trial in 3- to 6-year-old children treated with 6 mg of iron as ferrous sulfate per kilogram of body weight either daily, weekly, or twice weekly reported greater increases in hemoglobin concentration for all treatments than those obtained in the present study [29]. This difference may be partially due to the fact that the iron dose given was higher than that given in the present study. Other similar studies on young children reported lower increases in hemoglobin concentration, possibly due to the shorter duration of the studies (only 8 to 9 weeks of iron supplementation) [24, 31] or the lower iron dosage (3 to 4 mg of iron per kilogram of body weight [30].

Liu et al. [29] showed that after 3 months of supplementation of young anemic children at 6 mg of iron per kilogram of body weight, serum ferritin concentrations increased in proportion to total iron intake over the course of the study, with the highest increase (55.2 μg/L) in the children receiving daily supplementation, the lowest increase (26.7 μg/L) in the children receiving weekly supplementation, and an intermediate increase (48.1 μg/L) in the group receiving twice-weekly supplementation. In contrast, in our study the final serum ferritin values and changes in serum ferritin were similar for the groups receiving the three iron regimens. This difference in results cannot be easily explained. The parents were thoroughly informed about the nutritional aspects of iron-deficiency anemia, particularly about inhibitors of iron absorption such as tannins and enhancers of iron absorption such as ascorbic acid. The parents were advised to improve their children's intake of iron-rich foods such as meat, fish, and poultry to increase intake of iron absorption enhancers and decrease intake of inhibitors of iron absorption. In a study conducted at Prince Hashim Military Hospital in Zarqa from February 2001 through February 2002 [35], it was observed that while 80% of the study children (n = 82) aged 8 to 24 months were not fed any foods from the meat group, 20% consumed meat at a low frequency during the last week or the last month of the interview period.

In a study by Schultink et al. [24], 30 mg of iron as ferrous sulfate was administered either daily or twice weekly to 2- to 5-year-old children. The increases in serum ferritin were lower than those observed in the present study. This difference may have been due to the smaller dosage of iron and the shorter duration of their study, which lasted for only 2 months.

Statistical analysis showed that there was no treatment effect on hemoglobin and serum ferritin values; therefore all data were pooled to evaluate the correlation coefficients of hemoglobin and serum ferritin before and after 3 months of iron treatment. The initial and final hemoglobin and serum ferritin values were significantly correlated (r = 0.31 and 0.36 for hemoglobin and serum ferritin, respectively). However, the increases in hemoglobin and serum ferritin values were negatively correlated ($p < .001$) with their corresponding initial values. The lower the initial hemoglobin and serum ferritin values were, the higher were the increases in their concentration after 3 months of iron treatment. Similar observations have been made by other researchers, such as Berger et al. [30] and Palupi et al. [32] In other words, the greater the severity of anemia, the better the response to iron treatment.

All subjects in all three groups became free of anemia after 3 months of iron treatment, except for one 4-year-old boy in group 1. This child initially showed a positive response when his hemoglobin increased by 1.0 g/dL, and his hemoglobin concentration increased from 9.1 to 10.1 g/dL over the course of the study. However, the boy was still anemic (hemoglobin ≤ 10.5 g/dL) after 3 months of treatment. The boy's mother reported that prior to iron treatment her son had no appetite and was very weak and lethargic, but that after iron treatment his food intake and activity level greatly improved. There are several possible explanations for the failure of treatment in this child. The mother may not have administered the correct dose of iron for the duration of the 3-month study. Another possibility is that although the child originally received a diagnosis of iron-deficiency anemia, over the course of the study he might have become deficient in one or more of the hematopoietic nutrients other than iron, such as vitamin A, copper, vitamin B_6, folic acid, vitamin B_{12}, and protein, among others [46]. In this case, treatment with iron alone would have been inadequate. Finally, although parasites are not generally a problem in Jordan, as discussed by Faqih and Qazaq [36], this child might have become infected during the study period with one of the parasites mentioned above [25] that prevented him from full recovery. The results suggest that parasites were not a problem for most children in this study, since iron-deficiency anemia was successfully treated in all children except for one.

This case may be of importance, although it is based on just one child. It emphasizes the point that in treating iron-deficiency anemia, the overall nutritional status should be managed well. In addition, the parasite problem should be addressed in the case of anemic children who do not fully respond to iron treatment.

We believe that the correction of iron-deficiency anemia applies to all study children. All children were diagnosed as having nutritional iron-deficiency anemia as indicated by a combined criterion of hemoglobin ≤ 10.5 g/dL and mean corpuscular volume ≤ 75 fL, or as indicated by a combined criterion of hemoglobin ≤ 10.5 g/dL, mean corpuscular volume ≤ 75 fL, and serum ferritin ≤ 12 μg/L for the 34 subject children, as discussed above. The findings that iron therapy resulted in normal hemoglobin values in almost all children and normal mean corpuscular volume in all children lead to the conclusion that iron was the effective nutrient responsible for correcting the diagnosed iron-deficiency anemia. Moreover, iron therapy resulted in significant increases in mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration in all three treatment groups.

The initial mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration values were low, as shown by comparison with the cutoff values that reflect low iron status obtained from the National Health and Nutrition Examination Survey (NHANES) II reference population. According to Gibson [39], mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration values are all low in iron-deficiency anemia, which is not the case in macrocytic anemia or anemia of chronic disease. The fact that mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration were initially low and increased significantly after iron treatment stresses the facts that the children had anemia due to iron deficiency and that all three iron treatment regimens had the same effect in improving the values of these red cell indices.

The results of this study regarding weekly iron treatment of young children are supported by experimental evidence in rats [26, 28] as well as by the results of several other studies in young children [24, 29–31], adolescents [32], pregnant women [22], and nonpregnant women [33].

Conclusions

Data from Jordanian children aged 2 to 6 years diagnosed with iron-deficiency anemia show that with nutritional counseling as a component of iron therapy, a dose of 5 mg of elemental iron (ferrous sulfate) per kilogram of body weight given twice or once weekly for a period of 3 months was just as effective as daily administration of the same dose for the same period in correcting iron-deficiency anemia. This result should stimulate a review of iron supplementation and treatment strategies for the prevention and control of iron-deficiency anemia in populations with a high prevalence of iron-deficiency anemia or in which people are at a high risk of developing iron-deficiency anemia. The efficacy of weekly iron supplementation in correcting iron-deficiency anemia should be studied in other groups of people at risk, such as pregnant women in Jordan. The optimal amount and particular type of supplement should also be investigated in young children.

References

1. Lonnerdal B, Dewey KG. Epidemiology of iron deficiency in infants and children. Ann Nestlé [Eng] 1995;53:1–7.
2. Stephenson LS. Possible new developments in community control of iron-deficiency anemia. Nutr Rev 1995;53:23–30.
3. UNICEF/Micronutrient Initiative. Vitamin and mineral deficiency. A Global Progress Report. 2004:19.
4. Yip R. Iron deficiency. Bull World Health Organ 1998;76(suppl 2):121–3.
5. Scrimshaw NS. Nutrition and health from womb to tomb. Food Nutr Bull 1997;18:1–19.
6. Vyas D, Chandra RK. Functional implications of iron deficiency. In: Stekel A, ed. Iron nutrition in infancy and childhood. Nestlé Nutrition Workshop Series Vol 4. New York: Raven Press, 1984:45–59.
7. Walter T. Non-haematological consequences of iron deficiency. Ann Nestlé [Eng] 1995;53:18–24.
8. Walter T. Effect of iron deficiency anemia on cognitive skills and neuron maturation in infancy and childhood. Food Nutr Bull 2003;24: S104–10.
9. Walter T. Infancy: mental and motor development. Am J Clin Nutr 1989;50:655S–61S.
10. Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. N Engl J Med 1991;325:687–94.
11. Seshadri S, Gopaldas T. Impact of iron supplementation on cognitive functions in preschool and school-aged children: the Indian experience. Am J Clin Nutr 1989;50(3 suppl)675–84; discussion 685–6.
12. Kretchmer N, Beard JL, Carlson S. The role of nutrition in the development of normal cognition. Am J Clin Nutr 1996;63:997S–1001S.
13. Pollitt E, Hathirat P, Kotchabhakdi NJ, Missell L, Valyasevi A. Iron deficiency and educational achievement in Thailand. Am J Clin Nutr 1989;50(3 suppl): 687–96; discussion 696–7.

14. Soewondo S, Husaini M, Pollitt E. Effects of iron deficiency on attention and learning processes in preschool children: Bandung, Indonesia. Am J Clin Nutr 1989;50(3 suppl):667–73; discussion 673–4.
15. Soemantri AG. Preliminary findings on iron supplementation and learning achievement of rural Indonesian children. Am J Clin Nutr 1989;50(3 suppl): 698–70; discussion 701–2.
16. Hurtado EK, Claussen AH, Scott KG. Early childhood anemia and mild or moderate mental retardation. Am J Clin Nutr 1999;69:115–9.
17. Angeles IT, Schultink WJ, Matulessi P, Gross R, Sastroamidjojo S. Decreased rate of stunting among anemic Indonesian preschool children through iron supplementation. Am J Clin Nutr 1993;58:339–42.
18. Bougle D, Laroche D, Bureau F. Zinc and iron status and growth in healthy infants. Eur J Clin Nutr 2000;54: 764–67.
19. Lozoff B, Wolf AW, Jimenez E. Iron-deficiency anemia and infant development: effects of extended oral iron therapy. J Pediatr 1996;129:382–9.
20. De Andraca I, Walter T, Castillo M. Iron deficiency anemia and its effects upon psychological development at preschool age: a longitudinal study. Nestlé Foundation Annual Report 1990;52–3.
21. West CE. Strategies to control nutritional anemia. Am J Clin Nutr 1996;64:789–90.
22. Ridwan E, Schultink W, Dillon D, Gross R. Effects of weekly iron supplementation on pregnant Indonesian women are similar to those of daily supplementation. Am J Clin Nutr 1996;63:884–90.
23. Ministry of Health/World Health Organization/Ministry of Agriculture. Nutrition in Jordan. A review of the current nutritional trends and major strategic directions of the national food and nutrition policy. Amman: WHO, 2002.
24. Schultink W, Gross R, Gliwitzki M, Karyadi D, Matulessi P. Effect of daily vs twice weekly iron supplementation in Indonesian preschool children with low iron status. Am J Clin Nutr 1995;61:111–5.
25. UNICEF/Ministry of Health. Study of intestinal parasites and anemia in 3rd, 4th and 5th grade schoolchildren in Jordan. Amman: Ministry of Health, 1995.
26. Viteri FE, Liu X, Tolomei K, Martin A. True absorption and retention of supplemental iron is more efficient when iron is administered every three days rather than daily to iron-normal and iron-deficient rats. J Nutr 1995;125:82–91.
27. Viteri FE. Control of iron deficiency anemia—new approaches. Bull Nutr Fnd India 1999;20(2):5–7.
28. Wright AJ, Southon S. The effectiveness of various iron-supplemented regimens in improving the Fe status of anaemic rats. Br J Nutr 1990;63:579–85.
29. Liu X-N, Knag J, Zhao L, Viteri FE. Intermittent iron supplementation in Chinese preschool children is efficient and safe. Food Nutr Bull 1995;16:139–45.
30. Berger J, Aguayo VM, Tellez W, Lujan C, Traissac P, San Miguel JL. Weekly iron supplementation is as effective as 5 day per week iron supplementation in Bolivian school children living at high altitude. Eur J Clin Nutr 1997; 51:381–6.
31. Palupi L, Schultink W, Achadi E, Gross R. Effective community intervention to improve hemoglobin status in preschoolers receiving once-weekly iron supplementation. Am J Clin Nutr 1997;65:1057–61.
32. Angeles-Agdeppa I, Schultink W, Sastroamidjojo S, Gross R, Karyadi D. Weekly micronutrient supplementation to build iron stores in female Indonesian adolescents. Am J Clin Nutr 1997;66:177–83.
33. Gross R, Schultink W, Juliawati. Treatment of anaemia with weekly iron supplementation. Lancet 1994; 344(8925):821 (letter).
34. Kakish S. The effectiveness of intermittent iron treatment of three to five years old Jordanian children with iron deficiency anemia. MS Thesis, University of Jordan, Amman, 2002.
35. Abu-Mweis S. The effect of food intake and frequency of iron dosage on the treatment of iron-deficiency anemia in Jordanian children aged 8 to 24 months. MS Thesis, University of Jordan, Amman, 2002.
36. El-Ghul T. Poverty alleviation for a stronger Jordan: a comprehensive national strategy. Ministry of Social Development. Amman: Jordan, 2002.
37. Dallman PR, Reeves JD. Laboratory diagnosis of iron deficiency. In: Stekel A, ed. Iron requirements in infancy and childhood. Nestlé Nutrition Workshop series volume 4. New York: Raven Press, 1984; 11–44
38. Centers for Disease Control. Recommendations to prevent and control iron deficiency in the United States. MMWR 1998; 47 (PR-3): 1–31.
39. Gibson RS. Principles of nutritional assessment. Oxford, UK: Oxford University Press, 1990.
40. Murray MT. Encyclopedia of nutritional supplements. Rocklin, CA, USA: Prima Publishing, 1996.
41. Yip R, Dallman PR. Iron. In: Ziegler EE, Filer LJ, eds. Present knowledge in nutrition. 7th ed. Washington, DC: ILSI Press, 1996.
42. Faqih AM, Qazaq HS. Development of iron deficiency anemia at six months of age in Jordanian infants exclusively breastfed for four to six months. Food Nutr Bull 1999;20:422–8.
43. Hallberg L. Bioavailability of dietary iron in man. Annu Rev Nutr 1981;1:123–47.
44. Dallman PR. Laboratory diagnosis of iron deficiency in infancy and early childhood. Ann Nestlé [Eng] 1995;53:8–14.
45. Izzat M, Faqih A, Naji A, Mousa R. The effectiveness of daily iron treatment compared to twice weekly of Jordanian children (8–24 months) with iron deficiency anemia. Arab J Food Nutr 2002;3:122–34.
46. Williams SR. Nutrition and diet therapy. 8th ed. St. Louis, MO, USA: Mosby-Year Book, Inc., 1997.

Maternal nutritional status in pastoral versus farming communities of West Pokot, Kenya: Differences in iron and vitamin A status and body composition

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Abstract

Background. *Underweight and micronutrient deficiencies are sequelae of the prevailing harsh living and economic conditions of women in sub-Saharan Africa. There are few data describing maternal nutritional status in these resource-poor settings. Provision of more effective modes of intervention requires that public health and nutrition policy at both the national and the multisectoral levels be based on community-specific nutritional and behavioral practices.*

Objective. *This longitudinal study investigated maternal micronutrient status in two remote, semiarid, rural communities that are ethnically similar but have distinctly different pastoral and farming lifestyles. We looked at differences in iron stores, vitamin A levels, and body composition of women in the third trimester of pregnancy and again at 4 months postpartum.*

Methods. *Complete data were collected from 113 pastoral and 110 farming Pokot women. Anthropometric measurements were taken, and serum ferritin and retinol levels were measured. Infants were weighed within 7 days of birth.*

Results. *Women from the farming community had significantly* ($p < .05$) *lower hemoglobin concentrations than women from the pastoral community during the third trimester of pregnancy. Pastoral women had significantly higher serum ferritin concentrations than farming women during the third trimester of pregnancy* ($p < .05$) *and at 4 months postpartum. There were no significant differences between pastoral and farming women in the percentage of women with serum retinol levels < 0.70 µmol/L during the third trimester of pregnancy (27.9% [34/113] and 24.2% [31/110], respectively) and at 4 months postpartum (29.2% [33/113] and 30.9% [34/110]) In the farming community, mean infant birthweight was significantly lower* ($p < .01$) *than in the pastoral community and a significantly higher* ($p < .05$) *proportion of newborns weighed less than 2.5 kg. At 4 months postpartum, the percentage of body fat was significantly lower in pastoral women than in farming women.*

Conclusions. *Women from the farming community in West Pokot, Kenya, have lower iron stores during the third trimester of pregnancy than women in the pastoral community. In addition, the mean weight of their newborn infants is lower than that of infants in the pastoral community. These findings may be associated with differences in living conditions, which are usually harsher in farming than in pastoral communities.*

Key words: Body composition, pregnancy outcome, serum ferritin, serum retinol

Introduction

In many rural societies in sub-Saharan Africa, the status and quality of life of women are inseparably linked to the environment and sociocultural systems that determine their way of life. Lifestyle, as determined by remote, drought-prone rural environments, has exposed pregnant and lactating women to low food intake levels and very limited access to health services. Though the resulting maternal deficiencies in micronutrients such as iron and vitamin A have well-recognized health consequences [1–4], the very few studies done in Kenya have mainly looked at maternal body composition [5, 6] and at pregnancy loss and outcome [7, 8].

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In the remote semiarid areas of rural Kenya, different communities may have similar ethnic backgrounds but divergent pastoral and farming ways of life. In both the pastoral and the farming lifestyles, women tend to be overworked due to too many demands on their time. For the pastoral woman, herding the family goats is a key responsibility. In farming communities, the family's food security depends on the woman's ability to dig, plant, weed, and harvest food crops.

In recent years, consecutive droughts have left families in both types of community at risk of starvation. The poor household food security has become a priority issue for both the government and the World Food Program (WFP). HIV/AIDS and endemic malaria are becoming increasingly significant public health problems. Though consumption is frequently limited, meat and blood remain the key foods in the diet of pastoral women. For this reason, a pastoral lifestyle is likely to have a more positive effect on maternal nutritional status during pregnancy and lactation than a farming lifestyle. The objective of this longitudinal study was therefore to investigate maternal micronutrient status in two rural communities that are ethnically similar but have distinctly different lifestyles. We looked at differences in iron and vitamin A stores and body composition of women in the third trimester of pregnancy and again at 4 months postpartum. Infants were weighed within 7 days of birth and the prevalence of birthweight < 2.5 kg was determined.

Methods

Study area

The Pokot community values its traditional way of life and has consistently remained largely unaffected by the forces of modernization [9]. Cattle occupy a central part of the economic and social life of the community. Although the farming and pastoral communities of Pokot reflect different ecological situations, their basic cultural outlook is the same. About 85% of the Pokot people are pastoralists. They move in seasonal cycles to search for water and pasture for their stock. The agricultural people of Pokot are grouped into sprawling villages made up of more permanent homesteads.

The study area was in West Pokot District. Two study clusters based on a farming and a pastoral lifestyle were identified. The farming cluster consisted of the Sobokwo and Kerelwa sublocations and the pastoral cluster of the Ortum, Morbus, and Shepkobegh sublocations. Administratively a sublocation is further divided into distinct villages administered by locally selected village elders. In the pastoral communities of these sublocations, the older men, women, and children remain at more permanent homesteads with some livestock, mainly goats, while the young men are constantly on the move with their cattle seeking grass and water. Because of the limited annual rainfall in the Pokot farming communities, these communities have developed an extensive system of furrow irrigation for the cultivation of maize, sorghum, and millet.

Population

The longitudinal study was carried out from October 2001 to August 2002. Approval for the research was obtained from both the Moi University ethical and research committee and the Government of Kenya. At the time of the study, a comprehensive census of households with pregnant and lactating women and children under the age of five had just been carried out by the assistant chief and village elders of the five sublocations. This was done in preparation for possible future government food distribution. Each sublocation was administered by an assistant chief and had 10 to 12 villages. An updated register of pregnant women was compiled with the help of the village elders and the traditional birth attendants (TBAs) residing in each village. A total of 310 pregnant women were registered. All of the women had very limited access to prenatal care. Estimation of gestational age, a fundamental issue when repeated anthropometric measurements are considered, requires special facilities not usually available in African villages [10].

In the selection of subjects for our study, the women registered as pregnant were further interviewed to obtain information on the date of their last menstrual period. Their expected date of confinement was based on the fact that pregnancy lasts about 266 days (38 weeks) from the day of fertilization. The expected date of confinement was determined by counting back 3 months from the first day of the last menstrual period and then adding 7 days and 1 year. Under the field conditions in which the study was conducted, the information on the women's last menstrual period was then used to estimate gestational age. Those estimated to be between 28 and 36 weeks pregnant were considered to be in the third trimester of pregnancy and were identified as suitable subjects for the study. They were advised that the expected date of confinement was only an estimate and that birth could occur within 2 weeks before or after the calculated date. Infants born within this period were considered to be term babies [10].

The women gave informed consent before participating in the longitudinal study. One hundred twenty-two women from 8 pastoral villages and 128 from 6 farming villages were examined and recruited for the study. Most of the babies were born at home. The TBA and a research assistant carefully maintained a record of birthdates for all the infants.

Anthropometric measurements and blood collection

A precoded questionnaire was used to collect baseline information on demographic characteristics and pregnancy history. Anthropometric measurements made during pregnancy and lactation are expected to reflect both the nutritional status of the woman and, indirectly, growth of the fetus. Prepregnancy weight and prepregnancy body-mass index (the weight in kilograms divided by the square of the height in meters) are anthropometric measurements used to predict the risk of preterm delivery. In developing countries, prepregnancy values of maternal weight, height, or skinfold thickness are only seldom available. On the basis of the information provided by the World Health Organization (WHO) collaborative study [11] for anthropometric measurements made only once during pregnancy, mid-upper-arm circumference (MUAC), height, weight at any stage during pregnancy, and weight-for-height were identified as being of possible value for predicting maternal and fetal outcomes. MUAC is largely independent of gestational age and may be regarded as a proxy indicator of maternal prepregnancy weight or early pregnancy weight [12]. In addition, short maternal height has been associated with an increased risk of intrauterine growth retardation in several populations, and cutoff points between 140 and 150 cm have been proposed for screening [12].

The mother's body weight was measured to the nearest 0.1 kg with a calibrated electronic scale (SECA, Hamburg, Germany), and her height was measured to the nearest 0.1 cm with a height meter. A Holtain skinfold thickness caliper (Holtain, Croswell, UK) was used to make quadruple measurements of biceps, triceps, suprailiac, and subscapular skinfold thickness, which were used to determine maternal fat mass, percentage of body fat, and fat-free mass [13]. MUAC was measured with a nonextensible tape measure (UNICEF version). Repeated measurements were carried out by the same investigator. Low birthweight is an indicator of infant mortality risk, and in some populations a proportion of low-birthweight infants are a result of maternal undernutrition. In certain settings, however, improvement of maternal nutritional status may have no significant impact on infant mortality. Similarly, weight gain may be poor among pregnant women in a population with a high incidence of morbidity during pregnancy, and morbidity during pregnancy may have important effects on fetal development. Results from the WHO collaborative study [11] show that there is a strong correlation between a single measure of maternal weight late in pregnancy and the incidence of small-for-gestational age and low-birthweight infants. In this study, in order to determine pregnancy outcome, the infants were weighed at birth or within 7 days after birth. The infant's body weight was measured to the nearest 0.1 kg with a baby-weighing scale (SECA, Hamburg, Germany). There is evidence that poor postpartum status, as reflected in low body-mass index, is associated with poor lactation performance and poor infant growth, which suggests that body-mass index may be a useful indicator of postpartum nutritional status. Other factors likely to affect maternal health and for which we were not able to collect accurate data would include illness, food intake, and chronic diseases.

A nonfasting venous blood sample of 5 mL was collected from each woman during the third trimester of pregnancy and at 4 months postpartum and divided into plain (trace element free) and EDTA vacutainer (Becton Dickinson, Franklin Lakes, NJ, USA). The samples were stored on ice for transportation to the West Pokot Kapenguria District Hospital laboratory. The serum was separated for 15 minutes at 3,000 rpm, aliquoted, and frozen overnight at –20° C in the West Pokot Kapenguria District Hospital within 3 to 5 hours of sample collection. The next day the frozen samples were transported on dry ice to the Moi University laboratories in Eldoret, where they were stored at –70° C until analysis for serum retinol and ferritin.

Biochemical analysis

A Coulter counter model 560 (Coulter Electronics, Luton, England) was used to determine hemoglobin concentration and hematocrit. Serum retinol concentration was determined by high-performance liquid chromatography. Serum ferritin was measured by enzyme-linked immunoassay (ELISA) with a commercial kit (Boehringer Mannheim Immundiagnostike, Mannheim, Germany). A cutoff hemoglobin concentration of less than 110 g/L was considered to be low and possibly linked to anemia [1, 13]. Iron stores were characterized on the basis of serum ferritin concentration as severely depleted (< 12 μg/L), marginally depleted (12–29 μg/L), or normal (≥ 30 μg/L) [14]. Vitamin A status was characterized according to serum retinol concentration as deficient (< 0.35 μmol/L [10 μg/dL]) or marginal (0.35–0.70 μmol/L [20 μg/dL]) [15].

Statistical analysis

All statistical analyses were performed with the SPSS software package (Windows version 11.1); a p value < .05 was considered to indicate statistical significance. Normality of data distribution was checked by visual evaluation with the use of a histogram and the Kolmogorov–Smirnov test of normality. The Pearson chi-square and independent-samples t-test were used to compare groups for significant differences. Odds ratios were used to estimate the relative risk of undernutrition in pastoral as compared with farming communities.

Results

Characteristics of subjects

A total of 250 women from pastoral and farming villages who were in the third trimester of pregnancy were enrolled in the study. Of the original cohort, 116 women from pastoral villages and 114 from farming villages were examined at approximately 4 months postpartum. Fifty-three percent of woman from the pastoral communities and 54% of those from the farming communities had no formal schooling. The percentage of women who were primiparous was 10.7% in the pastoral communities and 8.5% in the farming communities; 22% of women in the pastoral communities and 22.7% of those in the farming communities had more than 4 children; and 39% of those in the pastoral communities and 24% of those in the farming communities had at least one child under 24 months of age. Among women from the pastoral communities, 122 pregnancies resulted in 116 births; among women from the farming communities, there were 128 pregnancies and 114 births. Complete data were obtained from 113 women from pastoral communities (92%) and 110 women from farming communities (85%).

TABLE 1. Body composition and pregnancy outcome of pastoral and farming Pokot women during the third trimester of pregnancy and 4 months after delivery (lactation) (mean ± SD)[a]

Characteristic	Pastoralists	Farmers
Age (yr)	26.8 ± 5.8	26.0 ± 6.2
Education (yr)	2.0 ± 2.6	2.2 ± 3.1
Parity[b]	3 ± 2	3 ± 2
Height (cm)	160 ± 5.6	160 ± 6.8
Weight (kg)		
Pregnancy	51.9 ± 5.5	51.6 ± 7.1
Lactation	50.0 ± 6.3	51.1± 7.1
BMI (kg/m^2)		
Lactation	19.7 ± 2.1	19.8 ± 2.6
% BF		
Pregnancy	21.7 ± 3.8	22.7 ± 4.5
Lactation*	24.2 ± 5.7	25.9 ± 5.1
FFM (kg)		
Pregnancy	40.5 ± 3.9	39.7 ± 4.7
Lactation	37.7 ± 3.7	37.6 ± 4.1
Infant weight (kg)[c]*	2.9 ± 0.4	2.8 ± 0.4

BMI, body-mass index; %BF, percentage body fat; FFM, fat-free mass

*$p < .05$; (independent *t*-test)

a. There were 122 pregnant and 113 lactating pastoral women and 128 pregnant and 110 lactating farming women.

b. Parity is the total number of live births.

c. Infants were weighed within 7 days after birth.

Body composition and pregnancy outcome

Descriptive statistics for maternal body composition and pregnancy outcome during the third trimester of pregnancy and at 4 months postpartum are given in **table 1**. The proportion of women with a low body-mass index (< 18.5 m/kg^2) at 4 months postpartum in farming and pastoral communities was 23% and 26.4%, respectively. At 4 months postpartum, the mean percentage of body fat was significantly ($p < .05$, *t*-test) lower in pastoral women (**table 1**). The mean infant weight measured within 7 days after birth as an indicator of pregnancy outcome was 2.856 ± 0.314 (SD) kg; 60% of the infants were male. The percentage of infants weighing less than 2.5 kg was 16.8% in the pastoral and 31.3% in the farming communities. The mean infant weight was significantly ($p < .01$, *t*-test) lower in the farming than in the pastoral communities (**table 1**). A significant ($p < .05$, χ^2 test) proportion of the newborns in the farming communities weighed less than 2.5 kg (**fig. 1**). Two children in the pastoral communities and five in the farming communities died soon after birth. The estimated relative risk of death was 2.4 times greater for infants born in the farming communities than for those born in the pastoral communities, probably because of the harsher living conditions in the farming communities.

Iron and vitamin A status

During the third trimester of pregnancy, the mean hemoglobin concentration was significantly ($p < .05$, *t*-test) lower in the pastoral than in the farming women (**table 2**). The percentage of women with low hemoglobin concentrations (< 110 g/L) in the third trimester was 42.2% in the pastoral communities and 21.8% in

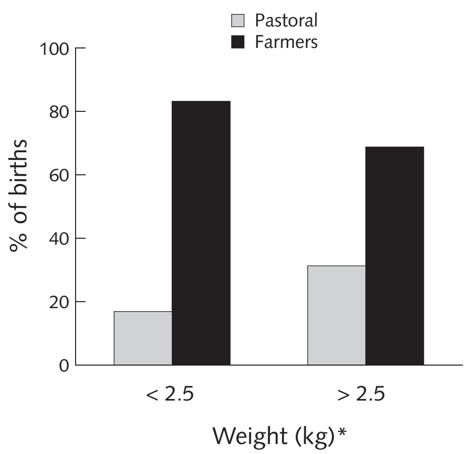

FIG. 1. Pregnancy outcomes: percentages of infants weighing less than and more than 2.5 kg born to pastoral and farming women

* Pearson χ^2, $p < .01$

the farming communities (**table 3**). In the pastoral communities, a significant ($p < .01$, χ^2 test) proportion of women had a reduced hemoglobin concentration during the third trimester of pregnancy. The mean serum ferritin concentration during the third trimester of pregnancy ($p < .05$, *t*-test) and at 4 months postpartum ($p < .01$, *t*-test) was significantly higher in the pastoral women than in the women from the farming communities (**table 2**). In the third trimester of pregnancy and at 4 months postpartum, the mean serum retinol concentration and the percentage of women with reduced vitamin A status did not significantly differ between the two communities (**tables 2** and **3**).

TABLE 2. Biochemical characteristics of pastoral and farming Pokot women during the third trimester of pregnancy and 4 months after delivery (lactation) (mean ± SD)[a]

Characteristic	Pastoralists	Farmers
Hemoglobin (g/L)		
Pregnancy*	119 ± 11.3	124 ± 15.0
Lactation	118 ± 10.0	119 ± 13.0
Hematocrit		
Pregnancy	33 ± 3.95	32 ± 5.42
Lactation	34 ± 2.71	34 ± 2.36
Serum ferritin (μg/L)		
Pregnancy*	25.8 ± 4.82	24.4 ± 4.87
Lactation**	18.5 ± 4.80	16.9 ± 4.38
Serum retinol (μmol/L)		
Pregnancy	0.92 ± 0.43	0.92 ± 0.35
Lactation	1.09 ± 0.47	1.11 ± 0.50

*$p < .05$; ** $p < .01$ (independent *t*-test)
a. There were 122 pregnant and 113 lactating pastoral women and 128 pregnant and 110 lactating farming women.

Discussion

Communities and individuals become vulnerable to undernutrition depending on their geographic and social characteristics, which influence livelihood opportunities. It cannot be assumed that figures that portray the national prevalence of undernutrition necessarily provide an accurate reflection of the plight of individual households in a remote district within a wider region.

There is a paucity of literature based on comprehensive empirical work at the community and individual levels. Though not frequently done, targeting interventions to particular geographic areas or socioeconomic groups is the most common and best-known application of anthropometric indicators. One of our aims as researchers was to facilitate future targeting for equity those deprived of access to social, health, and nutrition services. In economically disadvantaged populations, short stature in adults could also be used as an indicator of socioeconomic inequality. As they relate to maternal anthropometry, socioeconomic indicators would include body-mass index standardized for stage of pregnancy or measured during lactation as an overall indicator of the factors that affect women's energy balance [11]. Key among these are adequacy of food intake and morbidity experience coupled with a heavy workload and reproductive demands.

In the Pokot communities, inadequate food intake could be due to a number of factors. In the pastoral communities, the number of cattle that a person owns is a critical factor that determines the frequency of consumption of milk, blood, and meat. These foods are more nutrient-dense and more continually available than foods in the farming communities, especially during a drought. To supplement this diet, income from the sale of animals is used to buy maize. The main food crops in the farming communities are white

TABLE 3. Proportion of pastoral and farming Pokot women with low hemoglobin, serum ferritin, and serum retinol during the third trimester of pregnancy and 4 months after delivery (lactation)[a]

Variable	Pastoralists			Farmers			p (Pearson χ^2)
	N	%	95% CI	*N*	%	95% CI	
Hemoglobin (g/L)							
Pregnancy (< 110)	49	42.2	98–101	27	21.8	102–106	< .01
Lactation (< 120)	49	43.4	108–110	31	27.7	103–109	< .05
Ferritin < 32 μg/L							
Pregnancy	95	77.0	23.7–24.5	110	85.9	22.8–23.5	> .05
Lactation	111	98.0	17.8–18.6	109	99.0	16.3–17.1	> .05
Retinol < 0.70 μmol/L							
Pregnancy	34	27.9	0.41–0.45	31	24.2	0.47–0.53	> .05
Lactation	33	29.2	0.51–0.56	34	30.9	0.50–0.55	> .05

CI, confidence interval
a. There were 122 pregnant and 113 lactating pastoral women and 128 pregnant and 110 lactating farming women.

maize, sorghum, millet, and beans. Although some areas have irrigation systems, which are communally controlled and maintained, in a drought year the seasonal availability of food is reduced and household food insecurity becomes more acute. No cash crops are grown in the area, and sources of cash for purchase of maize are limited, especially in households where none of the members are formally employed [9].

Between 1989 and 2003, the infant mortality rate in Kenya increased from 60 to 78 per 1,000 births. The increase reflects the deterioration in quality of life over the last 20 years [16]. West Pokot is in the Rift Valley Province, where the infant mortality rate among women who have no education is 73.3 per 1,000 births [16]. In our study, the relative risk of infant death was 2.4 times greater in the farming communities. In both the farming and the pastoral communities, a large proportion of births took place at home. The early identification of infants with low birthweight is essential for any comprehensive initiative aimed at improving child survival. In Ethiopia, chest and head circumference have been used to identify infants with reduced birthweight, and these anthropometric measurements could also be used for this purpose by TBAs in the pastoral and farming Pokot communities [17].

In this study, the mean birthweight of the infants was the same as that of infants born to Turkana pastoral women (2.9 kg) [8]. The available data on infant birthweight tend to be based on deliveries occurring in hospitals and health centers. According to data from Kenya, the incidence of birthweights less than 2.5 kg is 9.3% [16]. An estimate of 11% has been made for other developing countries. Because of insufficient data, there have been no estimates for the East African region [18], and therefore our data provide valuable information on this topic. Our community-based data confirm the magnitude of the problem of low birthweight. The estimated incidence rates of low birthweight of 16.8% and 31.3% for pastoral and farming communities, respectively, in West Pokot are considerably higher than the national estimate based on hospital data. There is a possibility that the incidence of low birthweight was overestimated in our study because of the field conditions under which gestational age was determined. We did not have an effective method of identifying premature births, but a more effective method may be developed in future investigations. In this study the estimated risk of having an infant weighing less than 2.50 kg was 2.3 times greater for women living in farming communities than for those living in pastoral communities. Being born with low birthweight in a socioeconomically deprived community such as the Pokot farming community leads to negative health consequences that reverberate throughout the life cycle of an individual [18, 19]. The West Pokot District is one of the 10 poorest districts in Kenya, with about 43% of its population living at the poverty line* and 49% below the poverty line. Literacy levels have remained low. It is estimated that only 1.1% of individuals are formally employed [9].

In this study, changes in maternal body weight were minimal. Although a single measurement of maternal weight has been reported to be correlated with low birthweight [11], interpretation of maternal weight is constrained by the fact that it varies according to the mother's health and nutritional status, stage of gestation, physiological condition, and genetic background. Although total weight may be sensitive to these factors, it lacks specificity as an indicator. The large variation in weight within a specific height category has given rise to various expressions of weight-for-height, such as the body-mass index. A very low body-mass index is a fairly accurate reflection of severe wasting of both fat and lean tissue. Weight loss during lactation is variable and depends on socioeconomic status, weight gained during pregnancy, energy intake, and pattern of breastfeeding. Weight losses are highest in the first 3 months of lactation [20].

At 4 months postpartum, 23% of farming women and 26% of pastoral women had a body-mass index of less than 18.5 m/kg^2. The level of body-mass index below which there is a risk of poor lactation or infant growth has not been reported. It is possible to estimate a level based on the lower limit of body-mass index (< 18.5 m/kg^2) suggested for thin adults, adjusted for the average weight (4 kg) retained by mothers following an acceptable pregnancy weight gain (10.5 to 12 kg) and enough time for postpartum hydration to have equilibrated (2 to 4 weeks). In most cases, this results in an estimated cutoff for body-mass index of 20.3 m/kg^2 at 1 month postpartum for women 150 cm tall. Body-mass index may be expected to decline steadily throughout the first 6 months of lactation, at which point a value of 18.5 m/kg^2 for a nonpregnant, nonlactating woman can be used as a cutoff for identifying women at risk for chronic energy deficiency [11] .

Infections have a profound effect on nutritional status. West Pokot is a malaria-endemic area. During the 2003 Kenya National Demographic and Health Survey, the prevalence of HIV infection among women in the Rift Valley was 9.0% for those 20 to 24 years of age and 12.9% for those 25 to 29 years of age [16]. Multiple nutrients may play a role in protecting against or exacerbating malaria. A number of cross-sectional studies have shown an inverse relationship between vitamin A levels and the concentration of malaria parasites in the blood [21]. Earlier studies in which iron was given therapeutically, either as prophylaxis or for the treatment of iron deficiency, suggested that iron supplementation might be associated with an increased

* The poverty line is set as the cost of "normative basic needs" sufficient to reach a predetermined energy requirement.

incidence of clinical malaria [22, 23]. This suggestion has not been confirmed in studies conducted more recently [24, 25]. Nevertheless, a recent meta-analysis has shown that the evidence still favors a small but significantly increased risk of malaria following iron supplementation [26]. Relatively little is known about the converse association—that is , the incidence of malaria among iron-deficient persons. A recent Kenyan study found that the incidence of clinical malaria was significantly lower among iron deficient children and that the incidence of malaria was significantly associated with plasma ferritin concentration [27]. Iron supplementation programs in accordance with international dosing guidelines are appropriate for iron-deficient populations residing in malaria-endemic areas [21].

The prevalence of low maternal hemoglobin concentration (< 110 g/L) during the third trimester of pregnancy was significantly higher in pastoral than in farming women. The relative risk of low hemoglobin concentration was about 2.6 times higher for women living in pastoral communities than for those living in farming communities. The higher risk among pastoral women may be due not only to nutritional inadequacy but also to the fact that these women are more vulnerable to endemic malaria because they live in a hot savannah climate at lower altitudes. The problem is that infections such as malaria and HIV may induce an acute phase response that may increase serum ferritin concentrations and decrease hemoglobin concentrations. This might be the case for the pastoral Pokot women in our study. Chronic infection is another potential confounder of the biochemical iron indices that were used, and unfortunately we were unable to collect data on acute phase proteins such as C-reactive protein. Failure to consider the effects of the acute phase response results in a distorted estimate of the prevalence of iron deficiency [28]. Our data need to be interpreted with this in mind.

In this study, 25% of the Pokot women were found to have serum retinol concentrations of less than 0.70 μmol/L during pregnancy. In a national demographic survey carried out in 2003, 11.6% of pregnant women were reported to be night-blind [16]. Night-blindness is considered a proxy indicator of vitamin A status. Just as reported for iron indices [28, 29], surveys to estimate vitamin A deficiency should also include measurements of serum C-reactive protein. Omission of this assessment may have affected our estimates of serum retinol. A study by Sapin et al. [30] found that healthy, well-nourished pregnant women who reached full term had the same absolute quantities of retinol as nonpregnant women and that the lower concentrations of retinol in pregnant women who had reached full term were due to expansion of plasma volume.

In conclusion, life in the Pokot communities remains harsh and traditional. It is a life associated with poverty. The Pokot farming way of life was associated with negative changes in maternal body composition, iron stores, and vitamin A status during the third trimester of pregnancy and at 4 months after delivery. These factors may have partially determined pregnancy outcome. Pastoral and farming women were equally affected by the high prevalence of vitamin A deficiency and low iron stores. Although we recommend that intervention strategies aim at preventing reductions in maternal body composition and infant birthweight, we also point out that associations do not prove causality. Clearly the body composition, serum retinol concentration, and ferritin concentration of the women, especially of the farming women, are the result of complex interactions between physiological and environmental factors that may include low caloric intakes, high levels of physical activity, and coexisting diseases.

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References

1. Mejia LA. Role of vitamin A in iron deficiency anemia. In: Nutritional anemia. Fomon SJ, Zlotkin S, eds. Nestle Nutrition Workshop Series Vol 30. New York: Raven Press, 1992:93–101.
2. Dijkhuizen MA, Wieringa FT, West CE, Muherdiyantiningsih, Muhilal. Concurrent micronutrient deficiencies in lactating mothers and their infants in Indonesia. Am J Clin Nutr 2001;73:786–91.
3. Suharno D, West CE, Muhilal, Karyadi D, Hautvast JG. Supplementation with vitamin A and iron for nutritional anaemia in pregnant women in West Java, Indonesia. Lancet 1993;342(8883):1325–8.
4. Muslimatun S, Schmidt MK, Schultink W, West CE, Hautvast JA, Gross R, Muhilal. Weekly supplementation with iron and vitamin A during pregnancy increases hemoglobin concentration but decreases serum ferritin concentration in Indonesian pregnant women. J Nutr 2001;131:85–90.

5. Pike IL. Age, reproductive history, seasonality, and maternal body composition during pregnancy for nomadic Turkana of Kenya. Am J Hum Biol 1999;11:658–72.
6. Ettyang GA, van Marken Lichtenbelt WD, Esamai F, Saris WH, Westerterp KR. Assessment of body composition and breast milk volume in lactating mothers in pastoral communities in Pokot, Kenya, using deuterium oxide. Ann Nutr Metab 2005;49:110–7.
7. Leslie PW, Campbell KL, Little MA. Pregnancy loss in nomadic and settled women in Turkana, Kenya: a prospective study. Hum Biol 1993;65:237–54.
8. Pike IL. Pregnancy outcome for nomadic Turkana pastoralists of Kenya. Am J Phys Anthropol 2000;113:31–45.
9. Pkosing D, Krop S, Lopetakou W, Sikamov P. The Pokot land claims in Trans Nzoi District (1896–2002). Presented to the Constitution of Kenya Review Commission. Available at: http://www.kenyaconstitution.org. April 2002. Accessed 19 June 2006.
10. Kramer MS, McLean FH, Boyd ME, Usher RH. The validity of gestational age estimation by menstrual dating in term, preterm, and postterm gestations. JAMA 1988;260:3306–8.
11. Maternal anthropometry and pregnancy outcomes. A WHO Collaborative Study. Bull World Health Organ 1995;73(suppl):1–98.
12. Maternal nutrition and pregnancy outcome: anthropometric assessment. Scientific publication no. 529. Krasovec K, Anderson MA, eds. Washington, DC: Pan American Health Organization, 1991.
13. Gibson R. Principles of nutritional assessment. New York: Oxford University Press, 1990.
14. Yip R. Iron deficiency: contemporary scientific issues and international programmatic approaches. J Nutr 1994; 124(8 suppl):1479S–90S.
15. World Health Organization. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. WHO/NUT/96.10. Geneva: WHO, 1996.
16. Central Bureau of Statistics, Kenya. The Kenya Demographic and Health Survey 1993. Available at: http://www.cbs.go.ke. Accessed 19 June 2006.
17. Raymond EG, Tafari N, Troendle JF, Clemens JD. Development of a practical screening tool to identify pre-term, low-birthweight neonates in Ethiopia. Lancet 1994;344(8921):524–7.
18. United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition (ACC/SCN). Fourth report on the world nutrition situation. Nutrition throughout the life cycle. Geneva: ACC/SCN and International Food Policy Research Institute (IFPRI), 2000.
19. Allen LH, Lunga'aho MS, Shaheen M, Harrison GG, Neumann C, Kirksey A. Maternal body mass index and pregnancy outcome in the Nutrition Collaborative Research Support Program. Eur J Clin Nutr 1994;48(suppl 3):S68–76; discussion S76–7.
20. Brewer MM, Bates MR, Vannoy LP. Postpartum changes in maternal weight and body fat deposits in lactating vs nonlactating women. Am J Clin Nutr 1989;49:259–65.
21. Paton NI, Gassull MA, Cabre E. Infectious disease. In: Clinical Nutrition. Gibney MJ, Marinos E, Ljungqvist O, Dowsett J, eds. 1st ed. Oxford: Blackwell Science, 2005:324–44.
22. Oppenheimer SJ, Gibson FD, Macfarlane SB, Moody JB, Harrison C, Spencer A, Bunari O. Iron supplementation increases prevalence and effects of malaria: report on clinical studies in Papua New Guinea. Trans R Soc Trop Med Hyg 1986;80:603–12.
23. Smith AW, Hendrickse RG, Harrison C, Hayes RJ, Greenwood BM. The effects on malaria of treatment of iron deficiency anaemia with oral iron in Gambian children. Ann Trop Paediatr 1989;9:17–23.
24. Verhoef H, West CE, Nzyuko SM de Vogel S, van der Valk R, Wanga MA, Kuijsten A, Veenemans J, Kok FJ. Intermittent administration of iron and sulfadoxine-pyrimethamine to control anaemia in Kenyan children: A randomised controlled trial. Lancet 2002;360(9337):908–14.
25. Desai MR, Mei JV, Kariuki SK, Wannemuehler KA, Phillips-Howard PA, Nahlen BL, Kager PA, Vulule JM, ter Kuile FO. Randomized, controlled trial of daily iron supplementation and intermittent sulfadoxine-pyrimethamine for the treatment of mild childhood anemia in western Kenya. J Infect Dis 2003;187:658–66.
26. Shankar AH. Nutritional modulation of malaria morbidity and mortality. J Infect Dis 2000;182(Suppl 1): S37–53.
27. Nyakeriga AM, Troye-Blomberg M, Dorfman JR, Alexander ND, Back R, Kortok M, Chemtai AK, Marsh K, Williams TN. Iron deficiency and malaria among children living on the coast of Kenya. J Infect Dis 2004;190:439–47.
28. Thurnham DI, McCabe GP, Northrop-Clewes CA, Nestel P. Effects of subclinical infection on plasma retinol concentrations and assessment of prevalence of vitamin A deficiency: meta-analysis. Lancet 2003;362(9401):2052–8.
29. Wieringa FT, Dijkhuizen MA, West CE, Northrop-Clewes CA, Muhilal. Estimation of the effect of the acute phase response on indicators of micronutrient status in Indonesian infants. J Nutr 2002;132:3061–6.
30. Sapin V, Alexandre MC, Chaib S, Bournazeau JA, Sauvant P, Borel P, Jacquetin B, Grolier P, Lemery D, Dastugue B, Azais-Braesco V. Effect of vitamin A status at the end of term pregnancy on the saturation of retinol binding protein with retinol. Am J Clin Nutr 2000;71:537–43.

Constraints on good child-care practices and nutritional status in urban Dar-es-Salaam, Tanzania

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Abstract

Background. *Care is increasingly being recognized as a crucial input to child health and nutrition, along with food security, availability of health services, and a healthy environment. Although significant gains have been made in the fight against malnutrition in Tanzania, the nutritional status of preschool children in urban areas is not improving.*

Objective. *To assess child-care practices and the nutritional status of infants and young children with the aim of improving feeding practices and child nutritional status.*

Methods. *A cross-sectional study was undertaken in urban Dar-es-Salaam, Tanzania. The study involved 100 randomly selected mothers of children 6 to 24 months old from households in Ilala Municipality, one of the three municipalities that constitute the Dar-es-Salaam City Council. Data were collected by a structured questionnaire, spot-check observations, and anthropometric measurements.*

Results. *The prevalence rates of stunting, underweight, wasting, and morbidity were 43%, 22%, 3%, and 80%, respectively. The prevalence of exclusive breastfeeding was very low (9%), and most stunted children (88%) were not exclusively breastfed for the first 6 months. The mean age at which complementary foods and fluids were introduced was 3.26 ± 1.12 months (range, 1 to 5 months). The fluids given were mainly water and thin cereal-based porridge. More than half of the households practiced good hygiene. Most of the psychosocial practices (e.g., caregiver's attention, affection, and involvement in child feeding, hygiene, health care, and training) were performed by mothers, except for cooking and feeding the children and child training, which were done mostly by alternative caregivers. Nearly half of the mothers (44%) worked out of the home. The mean number of working hours per day was long (10.32 ± 2.13), necessitating the use of alternative caregivers. A negative correlation was found between height-for-age z-scores and the number of hours mothers worked outside the home.*

Conclusions. *The prevalence rates of chronic malnutrition and morbidity are high, and child-feeding practices are inadequate in this urban population. Maternal employment and educational characteristics constrain good child-care practices, and alternative caregivers are taking a more important role in child care as mothers join the work force. We recommend that formative research be conducted to study the actual practices of caregivers in order to form the basis for a child-care education program. There is also a need to strengthen national health system support for improved child feeding.*

Key words: Child-care practices, child-feeding practices, nutritional status, preschool children, Tanzania

Introduction

About one-third of the population of Africa live in urban areas, and this proportion is expected to increase to more than one-half by the year 2033 [1]. The average rate of urban population growth in East Africa from 1995 to 2025 is projected to be 4.7%, so that by the year 2025, 41.2% of the population in this region will live in urban areas [2].

Urbanization and changing food habits and lifestyles have placed an additional burden on nutritional problems in Africa. The incidence of malnutrition among preschool children (under 5 years of age) in low socioeconomic groups is on the increase [3]. Diversification of available food and better services can be viewed as factors that have positive nutritional outcomes. However, some studies have found that a cash economy in which most food has to be purchased and lessening of

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extended family interactions are among the factors that can lead to negative nutritional consequences [4, 5].

During the 1980s, there were three major types of specific national nutritional programs whose objective was to reduce the high rates of malnutrition and mortality: the Iringa Joint Nutrition Support Programme (JNSP), the Child Survival Protection and Development (CSPD) Programme, and the National Micronutrient Control Programme (NMCP). Although these programs were successful in terms of sustainability and reducing the very high rates of severe malnutrition [6], the nutritional status of young children has not improved. Data collected in the 1999 Tanzania Demographic Health Survey (TDHS) to assess the nutritional status of children under 5 years of age were similar to those obtained in the 1991–92 and the 1996 TDHS. The three surveys found that the prevalence of stunting has remained at around 43% to 44%. The prevalence of wasting rose from 6% to 7% from 1991–92 to 1996 and decreased to 5% in 1999. The proportion of underweight children remained constant at around 29% to 31% [7]. Deterioration in the nutritional status of children was shown to begin shortly after birth and continue through the first 18 months, and then to improve slightly thereafter to the third birthday [7].

Although significant gains have been made in the fight against malnutrition in Tanzania, the nutritional status of preschool children in urban areas is not improving. Conditions of urban poverty, the high proportion of women working outside the home, dependence on a cash income, and the unavailability of household resources (food, water, sanitation services, and alternative child caregivers) have been found to be the major constraints to good child-care practices in some African cities [1]. Care refers to the provision (in both the household and the community) of time, attention, and support to meet the physical, mental, and social needs of the growing child and other household members [8]. Care practices necessary for good growth and development in children under the age of 3 years include care for women; young child feeding, psychosocial stimulation, and support for development; food preparation, hygiene, and storage; personal hygiene practices; and home health practices. These care practices require human, economic, and organizational resources and support from the family [9].

Children's basic needs are the same in all cultures; however, care practices and resources vary greatly between cultures, and even within different groups within cultures. Widespread changes in society, such as urbanization and the changing economic role of women, require adaptations in care practices [9]. Understanding the importance of care practices would help identify good practices that should be encouraged and poor practices that should be corrected. Since performance of care practices requires enough resources for the caregiver to be able to put knowledge into practice, understanding the extent to which household resources influence child-care practices would contribute to the improvement of intervention strategies to address malnutrition among urban preschool children. The purpose of this study was to assess child-care practices and the nutritional status of children aged 6 to 24 months in Ilala Municipality, Dar-es-Salaam, Tanzania.

Subjects and methods

The study was carried out in Ilala Municipality of the Dar-es-Salaam region in December 2003. The region is located on the east coast of Tanzania, bordered by the Indian Ocean to the east and on all other sides by the Coast region. The estimated population of Dar-es-Salaam, according to the 2002 census, was 2,497,940 [10]. Ilala Municipality is one of three municipalities that constitute the Dar-es-Salaam City Council. It consists of three divisions: Kariakoo, Ilala, and Ukonga. Ilala was selected by simple random sampling, and three wards from Ilala (Buguruni, Vingunguti, and Tabata) were selected by systematic sampling. A sampling frame constituting households with children 6 to 24 months of age was constructed from each selected ward and the households were numbered. There were 98 households in Buguruni, 102 in Vingunguti, and 99 in Tabata. From each list, a random selection of every third household with a child 6 to 24 months of age was performed, resulting in a total of 100 study households—33 from Buguruni, 34 from Vingunguti, and 33 from Tabata. Ethical approval to conduct the study was obtained from the Office of the Vice-Chancellor, Sokoine University of Agriculture. Permission to conduct the study was obtained from the office of the Ilala Municipal Director.

A structured questionnaire was constructed and pretested on a group of nonparticipating mothers, and adjustments to the questions were incorporated accordingly. The pretested questionnaire was used to collect information from mothers with children between 6 and 24 months of age. It consisted of questions on background characteristics of parents (age, marital status, education level, and occupation) and households in general; feeding practices; use of preventive health services and morbidity of children; hygiene practices; psychosocial practices (e.g., caregiver's attention, affection, and involvement in child feeding, hygiene, health care, and training); and anthropometry. Hygiene practices were assessed and graded as "clean" or "not clean" by a spot-check approach [1], using observations of predetermined hygiene-related features of the caregiver, index child, house compound, and latrine. These features have been used in previous surveys as proxies for positive or negative behaviors, rather than observations of the behaviors themselves, and the method has been used in cross-sectional surveys [1].

Weight [11] was measured to the nearest 0.1 kg with a Salter scale (Model 235, CMS Weighing Equipment, London) while the children were minimally clothed and without shoes. Recumbent length was measured by a measuring board (Perspective Enterprises, Portage, MI, USA) with a movable foot piece and fixed headrest placed horizontally on a flat surface. With the child lying in the supine position, the length was recorded to the nearest 0.1 cm. The child's age was determined from the date of birth recorded on the clinic card. Three anthropometric indices—height-for-age, weight-for-age, and weight-for-height—were computed by comparing the child's measurements with the reference values of the US National Center for Health Statistics (NCHS) using the Epi-Info software program (Version 6.0; Centers for Disease Control and Prevention, Atlanta, GA, USA) [12]. The prevalence rates of stunting (low height-for-age), underweight (low weight-for-age), and wasting (low weight-for-height) were defined as the proportions of children who had index scores below –2 SD of the NCHS reference mean [12].

All questionnaires were checked in the field for completeness and consistency. All households gave oral consent to be interviewed after the study objectives were explained to them.

Data were entered and analyzed by the Statistical Package for the Social Sciences (SPSS) program (Windows version 9.0; Chicago, IL, USA). Means and SDs were computed for continuous variables, and frequencies and proportions were computed for categorical variables. Associations and relations between nutritional status indices and other variables were tested by chi-square and Pearson correlation tests, respectively. The level of significance was set at $p < .05$ for all analyses.

Results

Males headed 74% of the households and females 26%. The mean household size was 5.3 ± 2.2 (range, 3 to 17). The education levels of most of the male heads of the participating households ranged from primary to tertiary school. The main sources of income were from permanent employment (57%) and informal business (43%). The mean household income per year was US$1,030.40 (TSh. 1,137,570 ± 753.50).* Other household care resources are presented in **table 1**. The majority of the households occupied rented rooms (75%). All households had access to a protected water supply. Ninety-four percent of the households had access to running water outside their rooms or houses, and 6% had access to covered wells. More than half of the households used public pit latrines and public dumping bins for garbage disposal. Most households owned radios, furniture, and charcoal or kerosene stoves, but only 27% of households owned a television set.

TABLE 1. Distribution of selected care resources among households ($n = 100$)

Resource	% of households
Housing quality	
Satisfactory[a]	54
Good[b]	21
Very good[c]	25
Assets owned	
Radio	98
Television set	27
Furniture	96
Charcoal stove	93
Garbage disposal	
Public dumping bins	76
Dug household pits	24
Has protected water supply	100
Type of latrine	
Public pit	62
Private pit	30
Private flush	8

a. Rented rooms built of bricks, unplastered unpainted walls, ceiling board present, very small rooms and windows.
b. Rented rooms built of bricks, walls plastered with cement and painted, ceiling board present, small rooms and windows.
c. Rented house built of bricks, walls plastered with cement and painted, ceiling board present, large rooms and windows.

The mean age of the mothers was 27.9 ± 4.18 years (range, 18 to 37 years). The mean number of years of schooling for the mothers was 9.23 ± 3.43 (range, 0 to 16). Most of the mothers (94%) had some form of basic education; 82% had a high school education, 12% had professional certificates or diplomas, and 6% had no schooling at all. A large proportion (75%) of the mothers were married, 13% were not officially married but living with a partner, 7% were widows, and 5% were divorced. Ninety-five percent of the mothers who were not married or who were divorced reported receiving financial support from the child's father.

Forty-four percent of the mothers worked full-time and 30% were not employed (**table 2**). Of the 70 mothers who were working full-time or part-time, 37% were engaged in small businesses at home, 36% were traders in local markets, and 27% were formally employed as teachers, nurses, bar and restaurant attendants, and office and shop workers. The mean number of hours these mothers worked per day was 10.32 ± 2.13 (range, 4 to 14), and up to 67% of them worked 8 hours or more per day. Of the mothers who worked full-time, 57% employed alternative caregivers and 27% lived with their relatives who acted as alternative caregivers. The remaining 16% worked and looked after their children simultaneously.

* Exchange rate at the time of survey: 1US$ = 1,104 TSh.

TABLE 2. Distribution of maternal employment characteristics

Characteristic	% of mothers
Current employment (n = 100)	
Full-time housewife	24
Working part-time	26
Working full-time	44
Unemployed (looking for work)	6
Place of employment (n = 70)	
Home (n = 26)	37
Markets (n = 25)	36
Office, school, hospital, or shop (n = 19)	27
Child care (n = 70)	
Mother works and looks after child (n = 11)	16
Mother uses alternative child care	
Employs household help (n = 40)	57
Lives with a relative (n = 19)	27

The mean age of the children was 14.35 ± 5.97 months; 55% were girls. The mean birth order was 3.39 ± 1.19. The distribution of child nutritional status is presented in **table 3**. The prevalence rates of stunting, underweight, and wasting were 43%, 22%, and 3%, respectively. The mean height-for-age was –1.94 ± 1.18 z-score, the mean weight-for-age was –0.004 ± 0.93 z-score, and the mean weight-for-height was 1.68 ± 1.25 z-score. The prevalence rates of stunting by age were 100% for children aged 6 months (n = 5), 42.8% for those aged 7 to 11 months (n = 35), and 38.3% for those aged 12 to 24 months (n = 60).

A high proportion of children (80%) had been ill during the 7 days prior to the survey. Malaria accompanied by fever (40%), diarrhea (35%), and cough and cold (25%) were the major illnesses, and most children had more than one illness. The majority of the children (90%) were taken regularly to maternal and child health (MCH) clinics for growth monitoring. However, only 80% of the children had been taken to a clinic one month prior to the survey; 75% of these were older children (12–24 months) and 25% were younger children (7–11 months). The immunization rate was high, with 95% of the children having received a full course of immunizations before their first birthday.

Few mothers (9%) reported that their children had been exclusively breastfed for the first 6 months, and more than 80% of the mothers reported using water and thinly prepared porridge as complementary food (**table 4**). A smaller proportion of mothers had fed cow's milk, fruit juices, or commercial milk formulas to their infants. Of the children who were not exclusively breastfed, 1.1% were first given complementary foods or fluids at 1 month of age, 19.8% at 2 months, 57.1% at 3 months, 20.9% at 4 months, and 1.1% at 5 months.

A high proportion of mothers (78%) were breastfeeding at the time of the survey. All 6-month-old children (n = 5) were breastfeeding, as were 94% of those aged 7 to 11 months and 66.7% of those aged 12 to 24 months. Among the 22% of the children who were not breastfeeding at the time of the survey, the mean duration of breastfeeding was 11.91 ± 4.69 months. The minimum age at which complementary foods and fluids were introduced to these children was 2 months.

The mean age of introduction of complementary foods and fluids for all children was 3.26 ± 1.12 months. The most commonly given complementary food was a thin, cereal-based porridge made from maize, rice, or millet. As the child grew to accept the porridge, the mothers would introduce locally made cereal-legume or oilseed mixtures, with beans, groundnuts, and soybean most commonly given. The most frequently given reason for stopping breastfeeding was that the child was accustomed to other foods and fluids and was eating well, leading to refusal of the breast. There was a significant positive correlation between the age at

TABLE 3. Nutritional status of children according to age (n = 100)

Feature	0–6 mo (n = 5)	7–11 mo (n = 35)	12–24 mo (n = 60)
Stunting (no. of children)			
Normal	0	20	37
Stunted	5	15	23
Underweight (no. of children)			
Normal	5	26	47
Underweight	0	9	13
Wasting (no. of children)			
Normal	5	34	58
Wasted	0	1	2

TABLE 4. Child-feeding practices (n = 100)

Practice	% of children
Child breastfed exclusively	
Yes	9
No	91
Prelacteal feeds given (n = 91)	
Water	87
Fruit juice	36
Thin porridge	88
Cow's milk	23
Infant formula (Lactogen)	12
Powdered milk (Nido)	13
Mother's reason for introducing complementary foods (n = 91)	
Little milk from breasts	24
Resumed work	27
Advised by health workers	19
Food provides more nutrients	30

which complementary foods were introduced and the number of years of the mother's schooling (r = 0.296, p = .001).

Although there was no significant association between degree of stunting and whether or not the child was exclusively breastfed, 88% of the stunted children were not exclusively breastfed for the first 6 months. Complementary foods were introduced to these stunted children at 2 to 3 months (68%), 4 months (22%), and 6 to 7 months (10%). There was a significant association (p = .016) between degree of stunting and breastfeeding status at the time of the survey. Of those children who were not currently breastfeeding (n = 22), 72.7% were stunted. There was no association between a child's nutritional status and whether the mother worked outside the home. Although more than half (59.1%) of children whose mothers worked full-time (n = 44) were stunted, the association was not significant. However, there was a significant negative correlation between height-for-age z-scores of children and the number of hours per day mothers worked outside the home (r = -0.275; p = .035). The z-scores were found to be lower as the number of hours mothers worked away from home became greater.

Spot-check observations found that on the basis of all hygiene indicators observed, more than half of the households practiced good hygiene (**table 5**). Mothers performed most of the psychosocial practices investigated, that is, taking child to hospital and maternal and child health (MCH) clinics, cooking child's food but not feeding the child, bathing the child and washing child's clothes. However, alternative caregivers were more likely to cook for the children and feed them (64%) and to train them to stand, walk, and talk (60%) (**table 6**).

Discussion

Nutritional status

We assessed the nutritional status of children and child-care practices in households with children aged 6 to 24 months in urban Dar-es-Salaam. Nearly half (43%) of the children we studied were stunted. This prevalence was similar to the 43.8% reported by the Tanzanian Demographic and Health Survey (TDHS) in 1999 [7]. All study children 6 months of age were stunted, as were nearly half of those aged 7 to 11 months and half of those aged 12 to 24 months. The prevalence rates of wasting (3%) and underweight (22%) in this study were slightly lower than those documented in 1999 by the TDHS (5.4% and 29.4%, respectively). A review of global anthropometric data has shown that the prevalence of stunting in sub-Saharan African countries is usually about twice that of underweight [13]. Stunting was the only nutritional status index with children in the severe category. Eleven percent of the children in this study were found to be severely stunted, as compared with 17.1% in the 1999 survey. We observed that chronic malnutrition, as indicated by the high rate of stunting, was a significant health problem.

Our data are different from those reported in the 1999 survey by the TDHS, probably because the 1999 data were based on average values from a large sample of children 6 to 60 months of age. In addition, our survey was carried out in 2003, when a number of factors could have contributed to a decrease in the rate of wasting and underweight since 1999 in the urban area. These factors include improved access to healthcare services and management of childhood illnesses.

Stunting reflects the cumulative effects of numerous insults experienced by children during pregnancy, infancy, and early childhood, beginning at birth and continuing through the initial 18 months, after which it is irreversible. Faltering in length extends through the first 40 months of life, whereas faltering in weight is concentrated between 3 and 12 months [13]. After 12 months of age, a child may be stunted and of low weight-for-age; however, the weight-for-height ratio rapidly improves. This suggests that after 12 months, weight gain can be adequate even while the process of stunting continues for another 2 years [13]. Until recently the extent to which faltering in length and weight follow distinctly different age-specific patterns that most likely reflect different causal mechanisms was not widely appreciated [13].

TABLE 5. Hygiene behaviors (n = 100)

Observation	% of households
Child is clean[a]	73
Mother or caregiver is clean[a]	77
Compound is swept	75
Latrine is swept or mopped	62

a. Observations were made of hair, face, nose, hands, nails, clothes, and feet.

TABLE 6. Psychosocial practices of mothers and alternative caregivers (n = 100)

Practice	% of mothers	% of alternative caregivers
Cooking child's food	62	38
Cooking child's food and feeding child	36	64
Washing child's clothes	54	46
Bathing child	56	44
Taking child to maternal and child health clinic and hospital	90	10
Training child to stand, walk, and talk	40	60

The high rate of stunting of children at 6 months of age in this study is a clear indication of intrauterine growth retardation; however, we did not have records of birth length to substantiate this observation. Children's length at birth is rarely measured and recorded, unlike birth weight, which is routinely recorded. The high rate of stunting of children at 6 months of age could have been caused by harmful cultural practices that contribute to inadequate dietary intake during pregnancy and result in intrauterine growth retardation. Pregnant women living in Tanzanian coastal communities such as urban Dar-es-Salaam are generally advised by their elders to eat little food in order to avoid having a big baby, who will cause problems during childbirth. Without timely interventions, the child is born already short for his or her age and continues in this condition throughout early childhood, as we observed in nearly half of the children aged 7 to 11 months and half of those aged 12 to 24 months. With poor child-feeding practices (e.g., low rates of exclusive breastfeeding and early introduction of complementary foods of poor quality), such as those found in this study, the likelihood of growth faltering at 6 months or older is high. Stunting, accompanied by macronutrient and micronutrient deficiencies and high rates of infectious disease, is most prevalent in the first year of life [14]. The consequences of stunting include high susceptibility to infectious diseases due to lowered immunity caused by inadequate dietary intake, as well as delayed cognitive and motor development [13].

Feeding practices

A very low proportion of children (9%) in this study were exclusively breastfed for the first 6 months. Low rates of exclusive breastfeeding have also been documented by researchers in Tanzania [7, 15, 16]. In a 1999 TDHS survey, the proportion of children 6 to 24 months of age who were exclusively breastfed was 4.4% [7]. The rates of exclusive breastfeeding for children under 6 months of age during 1995–2002 have generally been low, not only in Tanzania (32%) but also in Kenya (5%), Zimbabwe (33%), and the sub-Saharan region (28%) [17]. The rate of breastfeeding in this study was high (78%); however, about one-third of children 12 to 24 months of age were not breastfed.

Early introduction of complementary foods was commonly practiced by the mothers, with the majority serving prepared porridge and water to their infants by the time they were 3 months of age. We observed that mothers were not following internationally recommended practices, which require exclusive breastfeeding up to 6 months, with introduction of complementary foods at 6 months while breastfeeding is continued [13, 18]. A significant ($p = .016$) association was observed between stunting and breastfeeding status. A high proportion of children who were not breastfeeding were found to be stunted. Since at least 66% of children 12 to 24 months of age and an even higher percentage of younger children were still breastfeeding, it is possible that something other than early cessation of breastfeeding was responsible for the rate of stunting observed. Stunting could have been a result of intrauterine growth retardation, low rate of exclusive breastfeeding, early introduction of low nutrient-dense complementary foods, and a high morbidity rate. It has been observed elsewhere that linear growth begins to falter at birth even when breastmilk meets the energy requirements of the growing infant [13].

Early introduction of complementary foods and fluids tends to displace breastmilk consumption, causing a decrease in milk output due to decreased production. In this study, early introduction of complementary foods and fluids could have displaced consumption of breastmilk and hence its benefits. On the other hand, the foods and fluids consumed, in most cases, are of low nutrient density, and thus are not able to meet a child's nutrient requirements. In this study the most common fluids given to children were water and a thin, cereal-based porridge. Low breastfeeding rates caused by early introduction of complementary foods have been documented to be a major cause of severe malnutrition among children under 2 years of age in central Tanzania [16].

Morbidity

The high rate of morbidity observed in this study was mainly due to diseases such as malaria (accompanied by fever), diarrhea, cough, and cold. No significant association was found between illness and nutritional status of the infants and children in this study; however, significant associations between illness and wasting or stunting have been reported in the Philippines [19]. Early introduction of complementary foods such as those observed in the present study is usually accompanied by the introduction of contaminants and foreign microorganisms to the infant's gut. This leads to increased exposure to enteropathogenic bacteria, resulting in diarrheal diseases. Frequent episodes of diarrheal diseases reduce the availability of nutrients. Young children in Tanzania have about five episodes of diarrhea annually, accounting for about 23% of pediatric admissions at the national referral hospitals [20]. Early introduction of complementary foods and fluids also tends to displace breastfeeding and thus leads to inadequate nutrient intake, lowered immunity accompanied by frequent infections, and subsequent impaired growth.

Immunization rate

A high (80%) rate of attendance at MCH clinics was observed in the present study; however, as children grew older the rate of attendance diminished, simply because older children were not brought to the clinics as frequently. Nearly all children (95%) had received all immunizations recommended for their age; those who had not been fully immunized had generally missed one or more of their diphtheria/pertussis/tetanus (DPT) vaccinations, which are given in a series of doses. A higher rate of attendance at MCH clinics in urban areas has also been observed in Tanzania [15].

Mother's level of education

The mother's educational level had no significant association with the likelihood of exclusive breastfeeding. However, there was a significant positive correlation between the number of years a mother spent at school and the age at which she introduced complementary foods to the child. The mean number of years of schooling for mothers in this study was relatively high (about 9 years), and the majority of mothers had a basic primary education. Nutrition is not taught as such in primary schools, and therefore most of the mothers would have lacked formal knowledge of child-feeding and care practices. A study in Lesotho showed that the association between maternal education and the child's nutritional status was independent of nutritional knowledge among poorer households, whereas among wealthier households the association was mediated through increased nutritional knowledge [21]. A similar independent effect of maternal education was reported in the Philippines [19].

Mother's work status

More mothers worked full-time than part-time, and a majority of those who were working were self-employed, working from home or at the local markets. About 27% of employed mothers were formally employed in the public or private sectors. The majority of the working mothers left their children in the care of alternative caregivers. Although a nonsignificant association was found between children's nutritional status and mothers' employment status, the prevalence of stunting was higher in children whose mothers worked full-time than in those whose mothers did not work full-time. Maternal employment may not be a constraint to child care, because mothers modified their work patterns to attend to their young children's needs [1]. The strategies by which mothers stop working, or work fewer hours, or take their infants to work may be successful in protecting their children but may seriously jeopardize their ability to generate income for the family [1]. The mean number of hours per day mothers worked full-time was high, and a majority of the mothers worked more than eight hours per day, which would make hiring an alternative caregiver for the child the best solution.

The benefits of having an alternative caregiver may be outweighed by the quality of child care he or she can provide, considering that most of the caregivers do not have experience and their level of education is low. In this study a significant negative correlation was found between children's nutritional status (length-for-age z-scores) and the number of hours the mothers worked outside the home. The z-scores decreased as the number of hours increased. With the mother working away from home most of the day, provisions for child care can be very important. The alternative caregivers were left to perform important care behaviors, such as preparing and cooking the children's food and feeding and training the children. The behavior of the caregiver has been documented to influence children's intake of complementary foods. Important caregiver behaviors include the level of encouragement provided to the child during feeding, the frequency of feeding, the quality of child–caregiver interaction, and the environment in which feeding takes place. If children are fed in places where there are many distractions, they do not consume the amount they would in environments more conducive to optimal eating [13]. Since most of the employed alternative caregivers are young and not mature enough to adhere to specific and regular care behaviors, their lack of responsiveness to the child during feeding and presumed lack of attention to feeding patterns could have reduced the food intake of the children, thus contributing to the chronic malnutrition observed in this study. No firm conclusions can be drawn regarding the behavior of the caregivers, because the actual practices were not studied.

Nutrition education that targets alternative caregivers may in the long run improve child-care practices. Trials in providing nutrition counseling to Brazilian mothers in health facilities resulted in positive responses in understanding and recalling breastfeeding and complementary feeding recommendations. Improvements in maternal knowledge about complementary feeding, the timely introduction of complementary foods, and the quality of foods and feeding practices resulted in significant increases in energy, nutrient intakes, and weight among children older than 6 months [22, 23].

Care resources

Household care resources were found to have no significant association with children's nutritional status and care received and thus may not limit mothers' ability to feed their children appropriately. The care resources included paternal marital status, educational level, occupation, and income; household size and quality; and ownership of assets. Similar findings were reported in another study carried out in Tanzania, in which household socioeconomic status, except for the ownership of a radio, had no significant association with child-feeding practices and nutritional status [15].

However, significant associations between household resources and care practices were found in Haitian communities [24].

Conclusions and recommendations

Our study assessed child-care practices and nutritional status of infants and young children in an urban setting and identified some constraints to good practices. The prevalence of chronic malnutrition and morbidity was high in the study population. Child-feeding practices were inadequate. Household care resources do not appear to influence children's nutritional status, whereas maternal employment and educational characteristics constrain good child-care practices. Alternative caregivers are taking a more important role in feeding and caring for children as mothers join the work force. Efforts to improve feeding practices and to relieve the constraints to the adoption of optimal practices could have a significant effect on child nutritional status in this population.

Continued emphasis on nutrition education before the child is born, during prenatal and antenatal visits, and during growth-monitoring visits could go a long way to motivating mothers to avoid the use of prelacteal feeds, maintain exclusive breastfeeding for a recommended period of time, introduce complementary foods at the appropriate time, and improve general child care. Contacts with mothers during vaccination could offer an opportunity for nutrition counseling. In addition to weight, length or height measurements should be routinely taken by health personnel during growth-monitoring visits so that they can detect early growth faltering. For all these recommendations to succeed, there is a need to strengthen the national health system's support for improved child feeding by coordinating activities with health professionals and ensuring that consistent support is given within the health system and communities.

Since few people attend colleges and universities that teach advanced courses in nutrition, teaching food and nutrition at the primary and secondary levels may reach a larger audience. This study provided no basis for conclusions regarding the behavior of the alternative caregivers, but we recommend that formative research be conducted to observe their actual practices. In addition, mothers, caregivers, and those who influence their decisions need nutrition and hygiene education messages that are easily understood and communicated in a manner that maximizes the likelihood of their being implemented.

References

1. Armar–Klemesu M, Ruel MT, Maxwell DG, Levin CE, Morris SS. Poor maternal schooling is the main constraint to good child care practices in Accra. J Nutr 2000; 130:1597–1607.
2. Engle PL, Menon P, Garrett JL, Slack A. Urbanization and caregiving: a framework for analysis and examples from Southern and Eastern Africa. Environ Urban 1997; 9:253–70.
3. Solomons NW, Gross R. Urban nutrition in developing countries. Nutr Rev 1995; 53(4 Pt 1):90–5.
4. Gabr M. Urban nutrition in developing countries with special emphasis on pre-school children. In: Proceedings of a workshop on urban nutrition. Lunteren, Netherlands: Foundation for the Advancement of Knowledge of Mother and Child in Developing Countries, 1990:3–6.
5. Shetty PS, Baskaran T, Muthayya S, Diggavi S, Peter S, Koshy L, Krishnamurthy W, Abraham U. Infant feeding practices, nutritional status and growth of pre-school children in an urban environment in India. In: Proceedings of a workshop on urban nutrition. Lunteren, Netherlands: Foundation for the Advancement of Knowledge of Mother and Child in Developing Countries,1990:21–2.
6. Kavishe FP, Mushi SS, eds. Nutrition relevant actions in Tanzania. Dar-se-Salaam: Tanzania Food and Nutrition Centre, 1993.
7. United Republic of Tanzania. Tanzania Reproductive and Child Health Survey 1999. Calverton, Md, USA: National Bureau of Statistics/Macro International, 2000.
8. International Conference on Nutrition. World declaration and plan of action. Rome: ICN, 1992.
9. World Health Organization. Feeding and nutrition of infants and young children: guidelines for the WHO European Region, with emphasis on the former Soviet countries. Copenhagen, Denmark: WHO, 2000.
10. United Republic of Tanzania. 2002 Population and Housing Census: General Report. Dar-es-Salaam: National Bureau of Statistics/President's Office Planning and Privatisation, 2003.
11. Jellife DB, Jeliffe EF. Community nutritional assessment with special reference to less technically developed countries. New York: Oxford University Press, 1989.
12. World Health Organization. Measuring change in nutritional status: guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups. Geneva: WHO, 1983.
13. Lutter C. Meeting the challenge to improve complementary feeding. SCN News 2003;27:4–9.
14. Dewey KG. The challenges of promoting optimal growth. J Nutr 2001;131:1879–80.
15. Shirima R, Gebre-Medhin M, Greiner T. Information and socioeconomic factors associated with early breastfeeding practices in rural and urban Morogoro, Tanzania. Acta Paediatr 2001;90:936–42.
16. Serventi M, Dal Lago AM, Kimaro DN. Early cessation of breast feeding as a major cause of severe malnutrition

in under twos: a hospital based case study—Dodoma Region, Tanzania. East Afr Med J 1995;72:132–4.
17. United Nations System/Standing Committee on Nutrition. 5th report on the world nutrition situation. Geneva: World Health Organization, 2004.
18. Pan American Health Organization/World Health Organization (PAHO/WHO). Guiding principles for complementary feeding of the breastfed child. Washington, DC: PAHO/WHO, 2003.
19. Ricci JA, Becker S. Risk factors for wasting and stunting among children in Metro Cebu, Philippines. Am J Clin Nutr 1996;63:966–75.
20. Kingamkono R, Sjogren E, Svanberg U, Kaijser B. Inhibition of different strains of enteropathogens in a lactic fermenting cereal gruel. World J Microbiol Biotechnol 1995;299–303.
21. Ruel MT, Habicht J-P, Pinstrup-Andersen P, Grohn Y. The mediating effect of maternal nutrition knowledge on the association between maternal schooling and child nutritional status in Lesotho. Am J Epidemiol 1992;135:904–14.
22. Santos I, Victora CG, Martines J, Goncalves H, Gigante DP, Valle NJ, Pelto GH. Nutrition counseling increases weight gain among Brazilian children. J Nutr 2001; 131:2866–73.
23. Valle NJ, Santos I, Gigante DP, Goncalves H, Martines J, Pelto GH. Household trials with very small samples predict responses to nutrition counseling intervention. Food Nutr Bull 2003;24:343–8.
24. US Agency for International Development (USAID). Childcare, nutrition and health in the central plateau of Haiti: the role of community, household and caregiver resources. Washington, DC: Academy for International Development/Food and Nutrition Technical Assistance Project (AED/FANTA), 2003.

Milk thickeners do not influence anthropometric indices in childhood

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Abstract

Background. *Pediatric obesity is an important risk factor for chronic diseases in adulthood. Some infant feeding practices may contribute to childhood obesity.*

Objective. *To investigate whether the introduction of milk thickeners to bottle-fed infants between 3 and 6 months of age was associated with higher anthropometric measurements and indices at 1 and 4 years of age.*

Methods. *A population-based birth cohort study was conducted in 1993 in the urban area of Pelotas, Brazil. Information was obtained at birth, at 1, 3, 6, and 12 months, and at 4 years. Data were analyzed from the 596 children for whom information was available from all follow-up visits. The exposure of interest was the use of milk thickener (flour added to cow's milk) between the third and sixth months of life. The outcomes investigated were weight and length/height and the anthropometric indices weight-for-age, length/height-for-age, and weight-for-length/height z-scores at 1 and 4 years.*

Results. *The prevalence of use of milk thickener at any time between the third and sixth months was 44.6%. In the adjusted analysis, children who received milk thickener were, on average, 160 g heavier and 0.5 cm longer at 1 year than those who did not receive it. Weight-for-age and length-for-age z-scores were positively associated with use of milk thickener. No association was observed between this feeding practice and weight-for-length z-score. In the adjusted analysis, no effect of use of milk thickener on any of the anthropometric outcomes studied was observed at 4 years.*

Conclusions. *No association was found between the use of milk thickeners and weight-for-length/height z-scores in the first and fourth years of life. Future studies in other contexts would be helpful to further test this hypothesis.*

Key words: Anthropometric indices, infant growth, milk thickeners

Background

Pediatric obesity is considered to be an important risk factor for chronic diseases in adulthood [1-3]. The ability to predict with certainty which babies will be heavy or obese during the first years of life, however, is limited [4]. Studies focused on the velocity of infant growth found that small-for-gestational-age babies that showed catch-up growth between birth and 2 years of age were heavier, taller, fatter, and had more central fat distribution at 5 years of age than other children [5].

Recent studies suggest that breastfeeding protects against overweight [6] and bottle-feeding puts infants at greatest risk for becoming obese [7]. Feeding infants from a bottle and the use of flour (milk thickener) to thicken cow's milk served in a bottle were common maternal practices in Brazil in 1993 [8]. For example, in a study conducted in 20 municipalities of the northeastern state of Alagoas, Brazil, 71% of the 191 children between 6 and 18 months of age from low-income families were receiving cow's milk thickened with cassava flour [9]. At 3 months of age, 33.9% of babies born in Pelotas in 1993 received cow's milk thickened with corn flour (Maizzena, Cremogena), rice flour (Arrozina), or other similar products. Adding these ingredients to children's food increases its energy density and makes it plausible that the products could increase the risk of overweight.

This study aimed to investigate whether the introduction of milk thickeners to bottle-fed infants between 3 and 6 months of age was associated with higher anthropometric measurements and indices at 1 and 4 years of age.

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Methods

During 1993, a population-based birth-cohort study was conducted in the urban area of Pelotas, Southern Brazil, including all 5,249 infants born alive in the five maternity hospitals of the city. In Pelotas, a highly urbanized city with a population of about 300,000 in 1993, more than 99% of all deliveries took place in hospitals. Two pediatricians and seven senior medical students interviewed all mothers soon after delivery with a pretested structured questionnaire. The children were weighed naked with 10-g precision scales and their supine length was measured with specially designed length boards (AHRTAG baby length measures, London). The newborn birthweight was recorded by the maternity hospital staff. Gestational age was assessed for all babies according to the Dubowitz score [10] in the first 24 hours after birth. The scales were checked weekly with standard weights. Standardized procedures were used in all measurements.

At birth (perinatal interview), the questionnaire focused on demographic, environmental, and socioeconomic variables, as well as on characteristics of the pregnancy, labor, and delivery and utilization of health care. Information was obtained at birth, at 1, 3, 6, and 12 months, and at 4 years. A detailed description of the methods of this study is given elsewhere [11]. At each follow-up visit, the mothers were interviewed at home by trained interviewers about characteristics of the infant's feeding, frequency of diseases, and utilization of health care using standardized questionnaires. At follow-ups, the children were weighed with portable scales (CMS Weighing Equipment, London) and had their supine length or height measured with boards manufactured locally according to international specifications (AHRTAG, London, UK). Weight for age, length/height-for-age, and weight-for-length/height z-scores were calculated according to the National Center for Health Statistics (NCHS) reference [12]. Data were analyzed from the 596 children for whom information was available from all follow-up visits.

The outcomes investigated were the anthropometric measurements (weight and length/height) and the indices weight-for-age, length/height-for-age, and weight-for-length/height z-scores in the first and fourth year of life. The exposure of interest was the use of milk thickener (corn or rice flour added to cow's milk) between the third and sixth months of life. The variable was categorized as "no" (children who were not receiving milk thickener at the third or the sixth month of life) and "yes" (children whose mothers reported the use of milk thickener at either the 3-month or the 6-month follow-up, or at both follow-ups).

Information on possible confounding factors of the association between the exposure of interest and the outcome was gathered from the perinatal and the 3-month interviews. From the perinatal interview, information was gathered on the maternal variables of family income, marital status, age, schooling, skin color (as a proxy for maternal race), and parity and the infant variables of occurrence of multiple births, birthweight, gestational age, and sex. Skin color was categorized as white or non-white per interviewer's observation. Information on episodes of diarrhea and cough, hospitalizations, type of feeding, weight, and length was obtained from the 3-month follow-up interview.

Family income in the month prior to delivery was expressed as minimum wages per month (equal to about US$50 in 1993). Women who were single, widowed, divorced, or living without a partner were classified as single mothers. Maternal age was defined as completed years at time of delivery and categorized as < 20, 20–24, 25–29, 30–34, or ≥ 35 years. The mother's formal education was categorized as 0, 1–4, 5–8, or ≥ 9 completed school years. Parity was the number of previous births and was categorized as 0, 1, 2, or ≥ 3. Low birthweight was defined as less than 2,500 g. Preterm birth was defined as birth at less than 37 weeks of gestational age. The pattern of breastfeeding at 3 months was categorized as exclusive breastfeeding (breastmilk without any milk, tea, water, or food), predominant breastfeeding (breastmilk with the addition of teas and/or water but without the addition of other milks or food), partial breastfeeding (breastmilk used in combination with formula milk or other foods), and no breastfeeding at all [13]. The breastfeeding variable was not assessed at the 6-month follow-up.

The child's weight at 3 months was recorded in grams. Episodes of diarrhea in the previous 15 days and episodes of cough in the previous 7 days were also recorded at the 3-month follow-up.

Associations between the use of milk thickener and the independent variables were analyzed by the chi-square test. Linear trend was tested for ordinal variables. The strength of the association was tested by linear regression analysis (crude and multivariable). All variables were tested as potential confounders of the association between the use of milk thickeners and growth at 12 months and 4 years of age [14]. Only potential confounders of the association between use of milk thickener and the anthropometric outcomes at the 0.20 significance level were entered in the multivariable analysis. Statistical significance was defined by a two-tailed p value below 0.05. All analyses were performed with STATA version 8.2 software.

The study protocol was approved by the Medical Ethics Committee of the Federal University of Pelotas, affiliated with the Brazilian Federal Medical Council. The mothers gave oral consent to participation in the study.

Results

The analyzed sample consisted of 596 children who were followed up on five occasions after birth up to four years of age. **Table 1** presents the distribution of the sample and the prevalence of the use of milk thickener according to independent variables.

Most of the mothers had family incomes of three minimal wages or less (61.1%), lived with a partner (87.8%), were white (78.5%), were between 20 and 33 years of age (72.2%), and had less than 9 years of formal education (74.3%). One-third of the mothers were having their first baby (34.1%). Of the newborns, 7.6% were low birthweight, 6.9% were preterm, and 1.2% belonged to multiple births. At the third follow-up, 8.6% of the children had had diarrhea in the last 15 days, 40.4% had had episodes of cough in the last 7 days prior to interview, and 6.2% of the children had had at least one hospitalization in the first 3 months of life. Regarding the pattern of breastfeeding in the third month of life, 6.5% (n = 39) were exclusively breastfed, 21.8% (n = 130) were predominantly breastfed, 30.0% (n = 179) were partially breastfed, and 41.6% (n = 248) were weaned.

The prevalence of use of milk thickener at any time during the third and sixth months of life was 44.6% (266 children). The use of milk thickener was reported by mothers or caregivers of 24.5% of the children at the third month and by 38.4% at the sixth month of life. The use of milk thickener at both follow-ups was reported by the mothers of 109 children (18.3%). The mothers of 330 children (55.4%) reported no use of milk thickener at all during the study period.

TABLE 1. Distribution of the sample and prevalence of use of milk thickeners between the third and six months of life, according to independent variables, Pelotas, 1993 (n = 596)

Maternal and child characteristics	No. (%)	No. (%) using milk thickeners	p
Monthly family income (minimum wages)			.4[a]
≤ 1	104 (17.5)	50 (48.1)	
1.1–3	266 (44.6)	117 (44.0)	
3.1–6	136 (22.8)	64 (47.1)	
6.1–10	53 (8.9)	24 (45.3)	
≥ 10	37 (6.2)	11 (29.7)	
Lives with a partner			.1[b]
Yes	523 (87.8)	227 (43.4)	
No	73 (12.2)	39 (53.4)	
Maternal age (yr)			.02[a]
≤ 19	88 (14.8)	48 (54.6)	
20–33	430 (72.2)	190 (44.2)	
≥ 34	78 (13.0)	28 (35.9)	
Maternal education (yr)			.07[a]
0	16 (2.7)	8 (50.0)	
1–4	140 (23.5)	67 (47.9)	
5–8	286 (48.1)	133 (46.5)	
≥ 9	153 (25.7)	58 (37.9)	
Maternal skin color			.1[b]
White	468 (78.5)	201 (43.0)	
Nonwhite	128 (21.5)	65 (50.8)	
Parity			.1[b]
0	203 (34.1)	96 (47.3)	
1	167 (28.0)	62 (37.1)	
2	116 (19.5)	52 (44.8)	
≥ 3	110 (18.4)	56 (50.9)	
Multiple birth			.03[b]
No	589 (98.8)	260 (44.1)	
Yes	7 (1.2)	6 (85.7)	
Low birthweight			.03[b]
Yes	45 (7.6)	27 (60.0)	
No	551 (92.4)	239 (43.4)	
Preterm birth			.4[b]
Yes	41 (6.9)	21 (51.2)	
No	555 (93.1)	245 (44.1)	
Sex			.02[b]
Male	301 (50.5)	148 (49.2)	
Female	295 (49.5)	118 (40.0)	
Diarrhea at 3 mo			.3[b]
No	545 (91.4)	240 (44.0)	
Yes	51 (8.6)	26 (51.0)	
Cough at 3 mo			.001[b]
No	355 (59.6)	138 (38.9)	
Yes	241 (40.4)	128 (53.1)	
Hospitalization at 3 mo			.004[b]
No	559 (93.8)	241 (43.1)	
Yes	37 (6.2)	25 (67.6)	
Breastfeeding pattern at 3 mo			<.001[b]
Exclusive	39 (6.5)	5 (1.9)	
Predominant	130 (21.8)	22 (8.3)	
Partial	179 (30.0)	86 (32.3)	
Weaned	248 (41.6)	153 (57.5)	
Weight at 3 mo (kg)			.02[a]
< 5.20	112 (18.8)	51 (45.5)	
5.20–5.64	124 (20.8)	63 (50.8)	
5.65–5.99	114 (19.1)	58 (50.9)	
6.00–6.49	124 (20.8)	54 (43.6)	
≥ 6.50	122 (20.5)	40 (32.8)	
Weight-for-age z-score at 3 mo			.02[a]
< 0	237 (39.8)	119 (44.7)	
0–<1	261 (43.8)	114 (42.9)	
≥ 1	98 (16.4)	33 (12.4)	

a. Test for linear trend.
b. Pearson χ^2 test.

Children of adolescent mothers and those from multiple pregnancies were given milk thickener more often than children of women more than 19 years old or from single pregnancies (**table 1**). Infant sex and weight at birth were also associated with the use of milk thickeners, with male children and those who had low birthweight showing higher frequencies than the others. Positive histories of respiratory symptoms (cough) in the week previous to the third month follow-up and of hospitalization before completing 3 months of life were associated with the use of milk thickener. Children completely weaned at the third month of life also had higher frequencies of use of milk thickener.

At 12 months of age, the number of infants classified at weight-for-length z-score > 2 SD of the mean was higher among those who did not consume milk thickeners than among those who did (9.7% and 5.3%, respectively; p = .04). After adjustment for maternal skin color and birthweight, no significant difference was observed between consumers and nonconsumers of milk thickeners (odds ratio 0.57, 95% confidence interval 0.29–1.11; p = .1). At 4 years of age, the prevalence of children with weight-for-height z-score > 2 SD of the mean was comparable between nonconsumers and consumers, 12.0% and 8.4%, respectively (p = .2), even after adjustment for potential confounding factors (odds ratio 0.78, 95% confidence interval 0.47-1.31; p = .3).

Table 2 shows the crude and adjusted analyses of the effect of the use of milk thickener between the third and sixth months of life on infant anthropometric measurements and indices at 12 months of life. In the crude analysis, no measurements or indices were associated with the use of milk thickener in the third to the sixth months of life. In the adjusted analysis, weight, length, and z-score of weight-for-age and length-for-age were associated with the use of milk thickener. Children who received milk thickeners were, on average, 160 g heavier at 1 year of age than those who did not (p = .04). The mean length of users of milk thickener was 0.5 cm greater than that of those who did not. Weight-for-age and length-for-age z-scores were positively associated with the use of milk thickener. On the other hand, no association was observed between this feeding practice and weight-for-length z-score (p = .8) at 1 year of age.

In **table 3**, in the crude analysis, the use of milk thickener was associated with weight and height, but in the adjusted analysis no effect of milk thickener use was observed in any of the anthropometric outcomes studied at 4 years of age.

Discussion

The current study documents that bottle-fed children who received milk thickeners between 3 and 6 months of age had greater weight and length and greater weight-for-age and length-for-age z-scores at 12 months of age. However, no increase in weight-for-length/height z-score at 12 months or at 4 years of age was observed.

The strengths of this study are based on the fact that it had a cohort design with primary data collected at birth and regularly at 3 months, 6 months, 1 year, and 4 years. In addition, it was possible to control for a number of factors known to be associated with feeding patterns in infancy. The main limitation of the study that needs to be considered is that it was not possible to record the amount of milk and the composition of the solid food at the studied intervals, so that it was impossible to calculate the total daily energy intake among children from each group at each follow-up.

Available data suggest that changes in dietary and

TABLE 2. Crude and adjusted analyses for use of milk thickeners in the complementary food between the third and sixth months of life over infant anthropometric outcomes at 12 months of age, Pelotas, 1993 (n = 596)

Anthropometric outcomes	Crude β coefficient (95% CI)	SE	p	Adjusted β coefficient (95% CI)	SE	p
Weight	0.009 (–0.203–0.222)	0.108	.9	0.160 (0.009–0.312)[a]	0.077	.04
Length	0.154 (–0.376–0.684)	0.270	.6	0.540 (0.141–0.939)[b]	0.203	.008
Weight-for-age z-score	–0.030 (–0.220–0.160)	0.097	.8	0.155 (0.013–0.296)[c]	0.072	.03
Length-for-age z-score	0.009 (–0.171–0.189)	0.092	.9	0.188 (0.051–0.325)[d]	0.070	.007
Weight-for-length z-score	–0.058 (–0.225–0.109)	0.085	.5	0.017 (–0.132–0.166)[e]	0.076	.8

a. Adjusted for maternal skin color, education, marital status, parity, multiple birth, birthweight, gestational age, sex, hospitalization, and weight at 3 months of age.

b. Adjusted for maternal skin color, age, education, marital status, parity, multiple birth, birthweight, gestational age, sex, cough, hospitalization, and length at 3 months of age.

c. Adjusted for maternal skin color, education, marital status, parity, multiple birth, birthweight, gestational age, cough, hospitalization, and weight-for-age z-score at 3 months of age.

d. Adjusted for maternal skin color, education, marital status, parity, multiple birth, birthweight, gestational age, cough, hospitalization, and length-for-age z-score at 3 months of age.

e. Adjusted for maternal education, skin color, parity, multiple birth, birthweight, gestational age, and weight-for-length z-score at 3 months of age.

TABLE 3. Crude and adjusted analyses for use of milk thickeners in complementary food between the third and sixth months of life over infant anthropometric outcomes at four years of age. Pelotas, 1993 (n = 596)

Anthropometric outcomes	Crude β coefficient (95% CI)	SE	p	Adjusted β coefficient (95% CI)	SE	p
Weight	0.389 (0.080–0.697)	0.157	.01	0.271 (–0.058–0.600)[a]	0.168	.1
Height	0.819 (0.243–1.394)	0.293	.005	0.512 (–0.096–1.119)[b]	0.309	.1
Weight-for-age z-score	–0.175 (–0.397–0.048)	0.113	.1	–0.123 (–0.347–0.101)[c]	0.114	.3
Height-for-age z-score	–0.109 (–0.303–0.085)	0.099	.3	–0.070 (–0.265–0.124)[d]	0.099	.5
Weight-for-height z-score	–0.145 (–0.350–0.059)	0.104	.2	–0.137 (–0.341–0.068)[e]	0.104	.2

a. Adjusted for maternal skin color and education, birthweight, sex, weight, and breastfeeding pattern at 3 months of age.
b. Adjusted for maternal skin color and education, parity, sex, and breastfeeding pattern at 3 months of age.
c. Adjusted for maternal age, multiple birth, and weight-for-age z-score at 3 months of age.
d. Adjusted for maternal age and skin color, multiple birth, and length-for-age z-score at 3 months of age.
e. Adjusted for maternal age.

lifestyle patterns, collectively known as the "nutrition transition," have led to a worldwide trend of increase in obesity [15, 16]. A trend toward obesity in children is more and more frequent in both developing and newly developed societies [17, 18]. Previous analyses from two of the birth cohorts of Pelotas, for example, showed that the prevalence of overweight among 4-year-old children increased from 4.9% in 1986 to 10.5% in 1997 [19].

A qualitative survey on child feeding and nutrition conducted in Pelotas [8] showed that flour was rarely added to powdered milk, full-fat cow's milk being more commonly used. This survey showed that some mothers greatly varied the kind of flour used in order to diversify the child's diet. Price and availability in the city were important factors that influenced the choice of flour. As reported by mothers, addition of flour to milk given to small children was a delicate point in the relationship between mothers and doctors. Doctors tried to persuade mothers not to add flour to the bottle of milk (because it would increase the amount of energy), but mothers, in general, did not comply with that recommendation. From the mothers' point of view, there were three objectives to adding flour to the milk: to extend the intervals between meals, to fatten the child, and to regulate digestion.

The first objective was associated with poverty because feeding the child with less milk reduced the expenditure on infant foods. It was also a way to train the child to live with moderation and within the limitations imposed by poverty. The second objective was to fatten the child. A fat child was appreciated by poor mothers as a sign of a wealthy family and a denial of poverty. The third was related to folk physiology. It was believed that milk thickeners refreshed and regulated the digestive system.

Another source of energy is the sugar added to cow's milk. However, in the Brazilian culture, children consuming cow's milk, with or without flour, typically also consume sugar added to the bottle. This addition of sugar to the bottle made it impossible to analyze its effects separately. Medical concerns regarding risk of overweight were plausible because of the higher energy value of infant milk preparations containing milk thickeners.

The association between the method of infant feeding and subsequent obesity has been debated for a long time, stimulated by research suggesting that bottle-fed infants are fatter than breastfed infants. Also, the age of bottle-weaning has been shown to be associated with overweight in young children [20–25]. In addition, many studies have reported an increased risk of overweight and obesity among children with early introduction of complementary foods [6, 26, 27]. In the present study, no difference was found between consumers and nonconsumers of milk thickeners regarding the timing of introduction of most of the solid foods investigated. Only vegetables were introduced at an early stage among children who consumed milk thickener; the difference between the groups was statistically significant.

In addition, after adjustment for potential confounding factors, no differences in z-scores of weight-for-length/height were observed between children who received milk thickeners and those who did not. This lack of association may be explained by concurrent breastfeeding [28, 29]. A retrospective cohort study showed that breastfeeding was associated with a reduced risk of obesity in white children whose mothers had not smoked during pregnancy. In this subgroup, the reduction in obesity risk, compared with those never breastfed, occurred only for children who were breastfed for at least 16 weeks without formula or at least 26 weeks with concurrent formula [30]. In the Pelotas sample, 32.3% of children consuming milk thickeners were partially breastfed at 3 months.

Another possible explanation for the observed results was the self-selection bias of the mothers, as a result of which babies with unfavorable characteristics (low birthweight, history of respiratory symptoms 1 week prior to the 3-month interview, history of hospital admission before the age of 3 months, low weight-for-age z-score at 3 months, and male sex) were chosen to receive cow's milk with flour. An anthropological study previously conducted in Pelotas [8] mentioned this as a strategy of mothers and caregivers to fatten the children.

Conclusions

In consideration of the fact that early infancy, together with gestation, is one of the critical periods for the development of obesity [31], and of the rapidity of early growth as well as the relative brevity of this first critical period, it is important to highlight the current opinion that, at the present time, breastfeeding and delayed introduction of solid foods are the safest known ways to prevent child overweight and obesity and perhaps adult obesity and its chronic complications. In the present study no association was found between the use of milk thickeners and anthropometric outcomes. However, other studies in other contexts would be helpful to test this hypothesis, so that clinical decisions can be supported by scientific evidence.

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References

1. Barker DJP, Osmond C, Winter PD, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. Lancet 1989;2(8663):577–80.
2. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med1997;337:869–73.
3. Guo SS, Roche AF, Chumlea WC, Gardner JD, Siervogel RM. The predictive value of childhood body mass index values for overweight at age 35 y. Am J Clin Nutr 1994;59:810–9.
4. Monteiro PO, Victora CG. Rapid growth in infancy and childhood and obesity in later life—a systematic review. Obes Rev 2005;6:143–54.
5. Eriksson JG, Forsen T, Tuomilehto J, Osmond C, Barker DJ. Early growth and coronary heart disease in later life: longitudinal study. BMJ 2001;322:949–53.
6. Grummer-Strawn LM, Mei Z. Does breastfeeding protect against pediatric overweight? Analysis of longitudinal data from the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System. Pediatrics 2004;113:e81–6.
7. Kral JG. Preventing and treating obesity in girls and young women to curb the epidemic. Obes Res 2004; 12:1539–46.
8. Nash CL. The role of culture in decision-making: infant feeding in Pelotas, Brazil (doctoral thesis). School of Public Health of the Johns Hopkins University: Baltimore, Md, USA; 1997.
9. Santos IS, Gigante DP, Coitinho DC, Haisma H, Valle NC, Valente G. Evaluation of the impact of a nutritional program for undernourished children in Brazil. Cad Saude Publica 2005;21:776–85.
10. Dubowitz LM, Dubowitz V, Goldberg C. Clinical assessment of gestational age in the newborn infant. J Pediatr 1970;77:1–10.
11. Weiderpass E, Cesar JA, Olinto MT, Guimaraes PR, Garcia MM, Vaughan JP. Longitudinal study of the mother and child population in an urban region of southern Brazil, 1993: methodological aspects and preliminary results [in Portuguese]. Rev Saude Publica 1996;30:34–45.
12. World Health Organization. A growth chart for international use in maternal and child health care. Geneva: WHO, 1978.
13. World Health Organization. Indicators for assessing breast-feeding practices. World Health Organization Division of Diarrhea and Acute Respiratory Disease Control. Geneva, WHO, 1991.
14. Rothman KJ, Greenland S. Precision and validity in epidemiologic studies. In: Rothman KJ, Greenland S. Modern epidemiology. 2nd ed. Philadelphia, PA, USA: Lippincott-Raven,1998:115–34.
15. Popkin BM. The nutrition transition: an overview of world patterns of change. Nutr Rev 2004;62:(7 pt 2):S140–3.
16. Monteiro CA, Moura EC, Conde WL, Popkin BM. Socioeconomic status and obesity in adult populations of developing countries: a review. Bull World Health Organ 2004;82:940–6.
17. Martorell R, Kettel Khan L, Hughes ML, Grummer-Strawn LM. Overweight and obesity in preschool children from developing countries. Int J Obes Relat Metab Disord 2000;24:959–67.
18. Wang Y, Monteiro C, Popkin BM. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China, and Russia. Am J Clin Nutr 2002;75:971–7.
19. Gigante DP, Victora CG, Araujo CL, Barros FC. Trends in the nutritional profile of children born in 1993 in Pelotas, Rio Grande do Sul, Brazil: longitudinal analyses [in Portuguese]. Cad Saude Publica 2003;19:(suppl 1): S141–7.

20. World Health Organization. Nutrient adequacy of exclusive breastfeeding for the term infant during the first six months of life. Geneva: WHO, 2002. Available at: http://www.who.int/child-adolescent-health/publications/nutrition/nutrient adequacy.htm. Accessed 21 June 2006.
21. Bonuck K, Kahn R, Schechter C. Is late bottle-weaning associated with overweight in young children? Analysis of NHANES III data. Clin Pediatr 2004;43:535–40.
22. Bonuck KA, Kahn R. Prolonged bottle use and its association with iron deficiency anemia and overweight: a preliminary study. Clin Pediatr 2002;41:603–7.
23. Bergmann KE, Bergmann RL, Von Kries R, Bohm O, Richter R, Dudenhausen JW, Wahn U. Early determinants of childhood overweight and adiposity in a birth cohort study: role of breast-feeding. Int J Obes Relat Metab Disord 2003;27:162–72.
24. Baker JL, Michaelsen KF, Rasmussen KM, Sorensen TI. Maternal prepregnant body mass index, duration of breastfeeding, and timing of complementary food introduction are associated with infant weight gain. Am J Clin Nutr 2004;80:1579–88.
25. Gunnarsdottir I, Thorsdottir I. Relationship between growth and feeding in infancy and body mass index at the age of 6 years. Int J Obes Relat Metab Disord 2003;27:1523–7.
26. Hediger ML, Overpeck MD, Ruan WJ, Troendle JF. Early infant feeding and growth status of US-born infants and children aged 4–71 mo: analyses from the third National Health and Nutrition Examination Survey, 1988–1994. Am J Clin Nutr 2000;72:159–67.
27. Kramer MS, Barr RG, Leduc DG, Boisjoly C, McVey-White L, Pless IB. Determinants of weight and adiposity in the first year of life. J Pediatr 1985;106:10-4.
28. Dewey KG. Is breastfeeding protective against child obesity? J Hum Lact 2003;19:9–18.
29. Arenz S, Ruckerl R, Koletzko B, von Kries R. Breast-feeding and childhood obesity—a systematic review. Int J Obes Relat Metab Disord 2004;28:1247-56.
30. Bogen DL, Hanusa BH, Whitaker RC. The effect of breast-feeding with and without formula use on the risk of obesity at 4 years of age. Obes Res 2004;12:1527–35.
31. Dietz WH. Critical periods in childhood for the development of obesity. Am J Clin Nutr 1994;59:955–9.

Vitamin A stability in salt triple fortified with iodine, iron, and vitamin A

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Abstract

Background. *Dietary micronutrient deficiencies, which lead to diseases such as iodine deficiency disorders, iron-deficiency anemia, and vitamin A deficiency, are serious public health problems in the developing world. Fortifying salt with iodine, iron, and vitamin A is an attractive approach to simultaneously reduce the deficiencies of these three micronutrients in the diet.*

Objective. *To explore the technical feasibility of producing triple-fortified salt fortified with iodine, iron, and vitamin A that would be stable under the climatic conditions of developing countries (i.e., high temperature and high humidity).*

Methods. *Triple-fortified salt was obtained by granulation and encapsulation of commercially produced vitamin A products, iodine, and iron compounds. Vitamin A retention was determined in the presence of five iron and two iodine compounds, in different combinations, under three different storage conditions. The influence of commercial stabilization techniques for the vitamin A palmitate source used (spray-dried or dissolved in oil), and the type of binder used for granulation on vitamin A retention in triple-fortified salt was studied. The influence of temperature, humidity, and chemical interactions on vitamin A stability in triple-fortified salt was also investigated.*

Results. *The most stable formulation retained 77.73% of vitamin A after 2 months of storage at 40°C, 60% relative humidity, and 95% under ambient conditions.*

Conclusions. *The results indicate that the production of a stable triple-fortified salt is technically feasible.*

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Key words: Salt fortification, vitamin A, iron, iodine

Background

More than two billion people in developing countries are at risk for iodine-deficiency disorders, iron-deficiency anemia, and vitamin A deficiency, at either clinical or subclinical levels, due to dietary deficiencies of iodine, iron, and vitamin A [1].

Inadequate iodine intake results in iodine-deficiency disorders that can include mental and physical retardation, goiter, cretinism, reproductive failure, and infant mortality. Low iron intake leads to anemia, which impairs the transport of oxygen and basic cell functions, affecting work performance and compromising immunocompetence [2]. Vitamin A deficiency has been shown to cause xerophthalmia, blindness, impaired growth and reproduction, and increased morbidity and mortality [3, 4]. The disorders caused by micronutrient deficiencies have huge social and economic costs to society, which could be eliminated by providing minute quantities of these nutrients daily. The most rapid, flexible, and economical way to increase the nutrient intake of a population is by food fortification. For example, iron fortification would cost only about US$0.20 per capita per year, iodine fortification about US$0.10 per capita per year, and vitamin A fortification about US$ 0.20 per capita per year [1]. Therefore, food fortification with all three of these nutrients could be achieved for about US$0.50 per person per year (in 2005).

However, the success of fortification programs depends on the food selected for fortification. The carrier selected for micronutrients has to be consumed by the vast majority of the target population, at a constant level every day, regardless of socioeconomic status, and have a low potential for excessive intake. Salt is a food ingredient that fulfills all of these conditions. Moreover, the salt iodization programs that are currently operating in about 110 countries have resulted in a significant decrease in iodine-deficiency disorders, proving the efficacy of salt as a food vehicle. Since the infrastructure for salt iodization exists in many countries, adding iron and vitamin A together with iodine to the salt would be the most efficient solution to increase the population's micronutrient intake. Moreover, the synergistic effects between iodine-deficiency disorders and iron-deficiency anemia [5] and between iron-deficiency anemia and vitamin A deficiency [6] suggest that the best approach to eliminate these deficiencies is to simultaneously fortify salt with all three micronutrients.

Our experience with double-fortified salt [7, 8] showed that when iron is introduced along with iodine into the salt, the interaction between iodine and iron results in a loss of iodine. Moreover, the ferrous iron is oxidized to ferric iron, which is less bioavailable and has a rusty color. Alkaline conditions, oxidizing agents, high temperature, and high humidity accelerate these reactions. Stable double-fortified salt was obtained by granulating iron and iodine compounds with an inert binder and microencapsulating the resulting particles with a polymer or fat. The granulation step is necessary to distribute the recommended daily dosage of iodine more evenly in the average daily consumption of 10 g of salt, and at the same time to increase the size of iodine and iron particles to that of salt crystals. The goal of encapsulation is to protect the nutrients in the core. By forming a physical barrier between the reactive components, microencapsulation improved iodine stability and eliminated problems related to the oxidation of iron.

Vitamin A is also a labile compound when exposed to high temperature, humidity, trace minerals, oxygen, or light.

Objective

The objective of this study was to test the use of microencapsulation for protecting commercially produced vitamin A formulations in salt in the presence of iodine and iron under expected conditions of salt production and distribution. We assessed the stability of vitamin A in triple-fortified salt prepared by using combinations of iron and iodine compounds, at three storage temperatures and humidities. The influence of three diluents, mannitol, lactose, and calcium sulfate dihydrate, on vitamin A stability in the presence of ferrous fumarate was determined. Two types of commercially produced vitamin A palmitate products were tested: spray-dried vitamin A palmitate starch coated supplied by Watson Foods, West Haven, CT, USA, and vitamin A palmitate dissolved in oil provided by BASF Corporation, Mount Olive, NJ, USA.

Materials and methods

Materials

Noniodized salt was obtained from Cargill Foods, Minneapolis, MN, USA. Laboratory-grade potassium iodide and electrolytic iron were purchased from BDH Chemicals, Toronto, Canada; potassium iodate, ferric sodium ethylenediamine tetraacetic acid, (FeNaEDTA), i.e., ethylenediaminetetraacetic iron (III), sodium salt hydrate, and iron (II) D-gluconate dihydrate were obtained from Aldrich Chemical Company, Milwaukee, WI, USA; and ferrous sulfate heptahydrate and ferrous fumarate were purchased from Sigma Chemical Company, St. Louis, MO, USA. The vitamin A sources were commercially manufactured vitamin A palmitate powder (250,000 IU/g) from Watson Foods and vitamin A palmitate oil from BASF Corporation. For vitamin A determination, vitamin A USP reference standard was purchased from USP Rockville, MD, USA; pyrogallol, isopropanol, and ethanol were obtained from Aldrich Chemical Company; hexane was supplied by EM Science, Gibbstown, NJ, USA; and potassium hydroxide was supplied by Caledon Laboratories, Georgetown, CA, USA. Hydroxypropyl methylcellulose was received from Dow Chemical Company, Toronto, and polyvinyl pyrrolidone was supplied by Sigma Chemical Company, St. Louis, MO, USA.

Soy stearine was supplied by CanAmera Foods, Toronto. The antioxidants butylated hydroxyanisole (BHA) and butylated hydroxytolouene (BHT), supplied by Sigma Chemical Company, were incorporated into the soy stearine at a level of 0.02%.

Equipment

Granulation and encapsulation were performed in two rotating stainless-steel coating pans with diameters of 26 cm and 13 cm respectively, each equipped with a variable-speed drive. Both the rotation speed of the pan and the pan inclination could be adjusted. A hand sprayer bottle of about 250 mL, purchased from Aldrich Chemical Company, was used for spraying the granulation solution and the encapsulant onto the particles from the pan. For particle separation, U.S. Tyler sieves and a Ro-Tap sieve shaker were used.

Premix preparation

Salt was double fortified with either potassium iodide or potassium iodate and one of the five iron compounds, ferrous fumarate, ferrous sulfate heptahydrate, ferrous gluconate, electrolytic iron, or FeNaEDTA. The required daily iodine intake is provided by approximately 15 ppm in salt, but industrial practice in most countries is to provide a significant excess, 100 ppm, for example, in North America, and 50 ppm in many developing countries. We chose 50 ppm as a conservative addition level, which also made the analysis more accurate. The methods selected for vitamin A introduction into salt were as follows:

» Creating a new particle by granulation and encapsulation that contains vitamin A as active ingredient;
» Introducing vitamin A together with iron into one particle so that the influence of the iron compound on vitamin A stability can be observed;
» Introducing vitamin A together with iodine into one particle; thus, triple-fortified salt will contain two particles: one that combines iodine and vitamin A and the other that contains iodine;
» Incorporating all three nutrients into a single particle.

The filler and binder used in this segment of the experiments was dextrin from Aldrich Chemical Company. The nutrient and the binder were first well mixed in a jar, followed by agglomeration with water in the pan. After granulation and recovery of particles in the 300- to 800-μm size range, the granules were pan encapsulated with 40% soy stearine, a fully hydrogenated vegetable fat. The resulting premixes were tested for iodine and vitamin A stability, where appropriate. Triple-fortified salt was prepared by adding the encapsulated ingredients to salt at a ratio of approximately 1:150 to obtain target levels for the micronutrients in salt: vitamin A approximately 250 IU/g salt, iron 1,000 ppm, and iodine 50 ppm. The list of formulations used in the final trials is presented in **table 1**.

Packaging and storage

Samples of about 100 g of triple-fortified salt were packed in Ziploc polyethylene bags. Samples of triple-fortified salt were stored under three different conditions: ambient temperature and humidity (~22°C, 50%–70% relative humidity, light), high temperature and medium humidity (40°C and 60% relative humidity, dark), and high temperature and high humidity (40°C and 100% relative humidity, dark). The environmental chambers used did not allow us to control lighting. Because light contributes to vitamin A degradation, the observed stability may be higher than in samples exposed to light. This problem could be prevented in the field by distributing salt in cardboard or using another light barrier, as it is in North America. Storage in the dark was not expected to greatly affect the conclusions of a preliminary study.

The samples were analyzed for vitamin A content immediately after mixing and after storage. We deliberately used extreme conditions for testing the system to get a feel for the maximum loss that could be expected. We have published the results of field tests with double-fortified and triple-fortified salt samples that were put through the commercial salt distribution system in Kenya. The results indicate that the assumptions made in this work regarding the expected temperatures and humidities are valid [9]. The sampling times were dictated by our ability to complete analyses, and therefore samples were not pulled after exactly 30, 60, 90, and 120 days, as would be ideal.

Influence of binders used for granulation on vitamin A retention

Vitamin A palmitate beadlets from Watson Foods were granulated with and without iodine with different binders: mannitol, lactose, and calcium sulfate dihydrate. Hydroxypropyl methylcellulose (HPMC) and polyvinyl pyrrolidone (PVP) were used to enhance the binding. The granulated particles were encapsulated with approximately 40% soy stearine. The iron source used was microencapsulated ferrous fumarate prepared in pilot scale tests we performed at Glatt Air

TABLE 1. Vitamin A retention (%) in triple-fortified salt where different fillers were used for granulation—vitamin A encapsulated separately[a]

Time (days)	Vitamin A retention (%)			
	Vitamin A granulated with mannitol and HPMC (I-1)	Vitamin A granulated with mannitol and PVP (II-1)	Vitamin A granulated with lactose and HPMC (III-1)	Vitamin A granulated with calcium sulfate dihydrate and HPMC (IV-1)
0	100	100	100	100
23	57.5	33.6	26.6	75
37	56	21.7	19.4	50
68	11	5.6	3.8	17.6
90	8	3.2	1.09	4.3

HPMC, hydroxypropyl methylcellulose; PVP, polyvinyl pyrrolidone

a. Source of iron: ferrous fumarate from Glatt Air Technique; source of iodine: potassium iodide from coating place. All types of granulations were coated in soy stearine (40%).

Techniques, Ramsey, NJ, USA. When vitamin A was granulated only with the binder without iodine, microencapsulated potassium iodide prepared in pilot-scale tests we performed at Coating Place, Madison, WI, USA, was used as the source of iodine. The salt was triple fortified at the target levels. Samples of triple-fortified salt were stored under conditions of high temperature and humidity. Samples were analyzed for vitamin A content immediately after mixing and four times during storage. Iodine content was determined once a month for a period of 3 months.

Vitamin A palmitate dissolved in oil

BASF Corporation supplied vitamin A palmitate oil stabilized with BHT (1.7 million IU/g), which is usually used for fortification of margarine and oils. Vitamin A palmitate dissolved in oil was introduced in the fat shell that protects the core containing potassium iodate and mannitol. The granules were coated with soy stearine in concentric layers: first a layer of soy stearine without vitamin A was applied, followed by another layer of soy stearine containing vitamin A, and finishing with another layer of soy stearine. Samples of triple-fortified salt made with the vitamin A and iodine premix and ferrous fumarate encapsulated at Glatt Air Techniques were stored at high humidity and temperature.

Analytical methods: Determination of vitamin A

Bags of salt were removed for analysis at three time intervals. The whole bag was subdivided with a two-necked funnel after remixing, with one of the streams representing half of the sample always rejected. A fluorometric method was used for vitamin A determination [10, 11] The method depends on excitation of the sample at 330 nm and measurement of retinol fluorescence at 480 nm. The intensity of the fluorescent emission was measured with a Perkin-Elmer Luminescence Spectrometer, LS 50B. To avoid exposure of vitamin A to light, the actinic glassware used in determination was covered with aluminum foil.

Since preliminary tests indicated no loss of iron and only small losses of iodine, the results for these micronutrients are not included in this article.

Results and discussion

Effects of iron and iodine compounds, temperature, and humidity on vitamin A stability

After 2 months of storage, the samples stored at ambient conditions and those stored at high temperature and moderate humidity were unchanged in color. All of the samples stored at high temperature and humidity changed color except the combinations in which FeNaEDTA was the iron source. The presence of the premix or premixes did not affect the caking of the salt, and the physical state of the salt had no effect on vitamin A retention. Adding an antislaking agent could resolve a caking problem in the field, but this was outside the scope of this study in any case.

Vitamin A retention for all combinations is presented in **table 2**. In 22 of 27 combinations, vitamin A retention under ambient conditions was higher than vitamin A retention at 40°C and 60% relative humidity or 40°C and 100% relative humidity, despite exposure to light under ambient conditions.

When all nutrients were encapsulated separately, the losses of vitamin A at high temperature and 60% relative humidity were 20% to 53% higher than the losses under ambient conditions, except for the combinations in which ferrous sulfate was used. When the active ingredients were encapsulated separately, the losses of vitamin A at 40°C and 100% relative humidity were 35% to 65% higher than under ambient conditions. This is not unexpected, since it is known from the

TABLE 2. Vitamin A retention (%) in triple-fortified salt where different fillers were used for granulation—vitamin A encapsulated with KIO_3[a]

Time (days)	Vitamin A retention (%)			
	Vitamin A and KIO_3 granulated with mannitol and HPMC (I-2)	Vitamin A and KIO_3 granulated with mannitol and PVP (II-2)	Vitamin A and KIO_3 granulated with lactose and HPMC (III-2)	Vitamin A and KIO_3 granulated with calcium sulfate dihydrate and HPMC (IV-1)
0	100	100	100	100
17	61.8	61.9	26.5	64.8
38	37	27	11.6	53
65	7.65	5.9	0.6	12.7
91	1.4	0.69	0.3	3.26

KIO_3, potassium iodate; HPMC, hydroxypropyl methylcellulose; PVP, polyvinyl pyrrolidone

a. Source of iron: ferrous fumarate from Glatt Air Technique. All types of granulations were coated in soy stearine (40%).

literature [12] that the dominant degradation reaction for vitamin A ester is heat-induced formation of kitols, which follows a second-order rate law. The rate of reaction increases significantly with temperature. Losses are significant (> 10%/month) even at 1°C in vitamin A acetate protected by a gelatin coat [13].

In combinations in which vitamin A was granulated with potassium iodate or potassium iodide, vitamin A retention was better than in cases where the nutrients were encapsulated separately. The best vitamin A retention at 40°C and 100% relative humidity, for all iron compounds, was obtained when vitamin A palmitate was granulated together with iodide. This is somewhat unexpected, since both potassium iodide and vitamin A are reducing agents susceptible to oxidation, whereas potassium iodate is an oxidizing agent. Dextrin might improve the stability of potassium iodide [14].

Halverson and Hendrick [15] reported that vitamin A loss was greater when trace minerals ($MnSO_4 \cdot H_2O$, $FeSO_4 \cdot 7H_2O$, $CuSO_4 \cdot 5H_2O$, and $CoSO_4 \cdot 6H_2O$) were present. In a feed concentrate, a vitamin A loss of 5.7% occurred during 150 days of storage in the absence of minerals, whereas the loss was 34.4% in the presence of minerals. Other authors [12] suggested that the presence of minerals does not greatly affect vitamin A retention. They observed a vitamin A loss of 70% without minerals and 64% with minerals after 16 weeks of storage. Clearly, metals in reactive forms would increase vitamin A degradation at a rate that depends on other conditions, such as moisture and temperature.

When vitamin A samples granulated with different iron compounds were stored at high temperature and humidity, the vitamin A retention was less than when vitamin A was granulated alone. Therefore, vitamin A is destabilized by iron present in the premix particle. Moreover, the most soluble types of iron, ferrous sulfate and ferrous fumarate, almost entirely destroyed the vitamin A. Vitamin A retention was higher in combinations in which more stable iron compounds were used, such as electrolytic iron, ferrous gluconate, or FeNaEDTA. The best vitamin A retention at high temperature and humidity was obtained with FeNaEDTA. This can be explained by the fact that the EDTA group is a chelating agent that binds tightly to the iron.

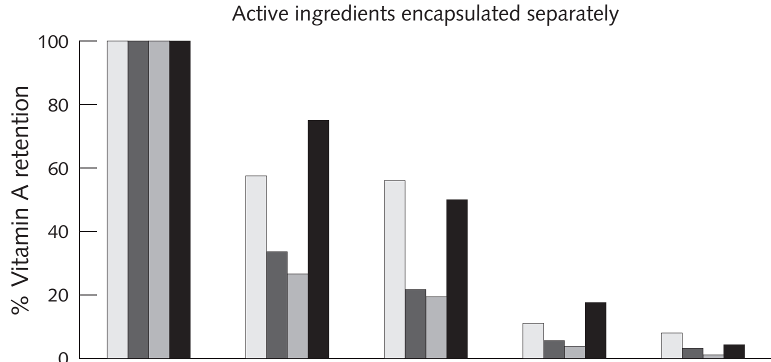
When vitamin A was encapsulated together with iodine compounds, the best vitamin A retention was obtained in the presence of potassium iodate for all types of iron compounds and under all storage conditions. When vitamin A was encapsulated together with iron compounds, the best vitamin A retention was obtained for FeNaEDTA, for both potassium iodide and potassium iodate under all storage conditions. Consequently, commercially produced vitamin A palmitate was granulated together with potassium iodate and FeNaEDTA. and the granules were encapsulated with approximately 40% soy stearine. Salt was fortified with this premix and stored under three different conditions. After 136 days of storage under ambient conditions, vitamin A retention was about 47%; at high temperature and 60% relative humidity, vitamin A retention was about 22%; and at 40°C and 100% relative humidity, vitamin A retention was only about 10%. By using FeNaEDTA as the iron source and potassium iodate as the iodine source, triple-fortified salt with barely adequate stability can be made with a single-component premix.

The salt did not discolor. The disadvantages of FeNaEDTA are its low iron content (about 15.2%), and high price.

Influence of binders used for granulation on vitamin A retention

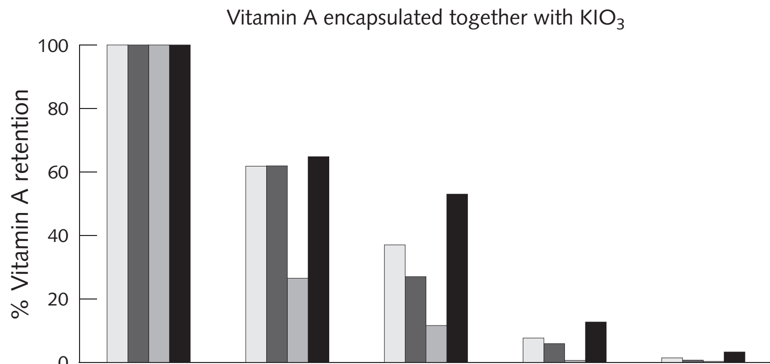
Most commercially produced vitamin A products are fine powders. To increase the bulk size of the nutrient to the size of salt crystals, a granulation step is required. Another reason for the granulation step is to dilute the nutrient so that it is uniformly distributed in 10 g of salt. The properties of the binder, which comes in close contact with vitamin A, may influence vitamin A stability. Therefore, in selecting the binders, their abilities to retain water and their reactivity were considered. The first category of binders selected included mannitol and calcium sulfate dihydrate. These have a very low affinity for water and are used especially in combinations where moisture may be a problem. The second category includes lactose. Lactose is hygroscopic but has good stability and does not interact with the other components of the particle. It could be a suitable binder in particles that have adequate encapsulation. **Figure 1** depicts vitamin A retention in triple-fortified salt when vitamin A was granulated alone using the binders mentioned above. **Figure 2** presents vitamin A retention when vitamin A was granulated with potassium iodate, using the same binders as when encapsulated alone. Vitamin A degradation followed different degradation kinetics with each type of binder used in granulation. For the nonhygroscopic binders mannitol and calcium sulfate dihydrate, the destruction of vitamin A seems to be linear, whereas for lactose vitamin A destruction seems to follow a second-order rate law. Both mannitol and calcium sulfate dihydrate resulted in slightly higher vitamin A retention, and mannitol resulted in less salt discoloration.

Slightly less vitamin A was retained when it was granulated with potassium iodate than when it was granulated alone, but this difference was not statistically significant. An analysis of variance (ANOVA) with type of introduction of iodine, i.e., separate and together with vitamin A, and type of binder showed that the type of binder has a very significant effect on vitamin A retention ($P_{max} = 99.9\%$), and by comparison the way that iodine is introduced into the system does not affect vitamin A retention ($P_{max} < 75\%$).



	0 days	23 days	37 days	68 days	90 days
☐ I-1 = 40%SS (Vitamin A + mannitol + HPMC)	100	57.5	56.0	11.0	8.0
■ II-1 = 40%SS (Vitamin A + mannitol + PVP)	100	33.6	21.7	5.6	3.2
■ III-1 = 40%SS (Vitamin A + lactose+ HPMC)	100	26.6	19.4	3.8	1.09
■ IV-1 = 40%SS (Vitamin A + $CaSO_4 \cdot 2H_20$+ HPMC)	100	7.05	50.0	17.6	4.3

FIG. 1. Vitamin A retention (%) in triple-fortified salt where different fillers were used for granulation. Source of iron: ferrous fumarate from Glatt Air Technique; source of iodine: potassium iodide from Coating Place. KIO_3, potassium iodate; HPMC, hydroxypropyl methylcellulose; PVP, polyvinyl pyrrolidone; SS, soy stearine



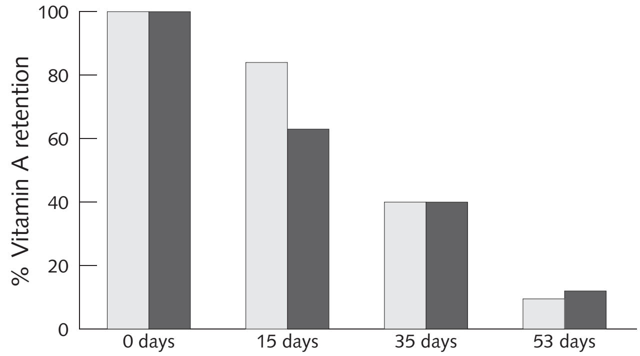
	0 days	17 days	38 days	65 days	91 days
☐ I-2 = 40%SS (Vitamin A + KIO_3 + mannitol + HPMC)	100	61.8	37.0	7.65	1.4
■ II-2 = 40%SS (Vitamin A + KIO_3 + mannitol + PVP)	100	61.9	27.7	5.9	0.69
■ III-2 = 40%SS (Vitamin A + KIO_3 + lactose+ HPMC)	100	26.5	11.6	0.6	0.3
■ IV-2 = 40%SS (Vitamin A + KIO_3 + $CaSO_4 \cdot 2H_20$+ HPMC)	100	64.8	53.0	12.7	3.26

FIG. 2. Vitamin A retention (%) in triple-fortified salt where different fillers were used for granulation. Source of iron: ferrous fumarate from Glatt Air Technique. KIO_3, potassium iodate; HPMC, hydroxypropyl methylcellulose; PVP, polyvinyl pyrrolidone; SS, soy stearine

Spray-dried versus oil-dissolved vitamin A palmitate

Vitamin A retention in triple-fortified salt when vitamin A palmitate dissolved in oil was introduced into the fat shell that protected the potassium iodate–mannitol core was compared with vitamin A retention where vitamin A palmitate spray-dried was introduced into the core along with potassium iodate and mannitol. The vitamin A retention is presented in **figure 3**.

After 53 days of storage at 40°C and 100% relative humidity, the retention was 9.5% for vitamin A palmitate oil and 12% for spray-dried vitamin A palmitate. The graph indicates that initially the vitamin A in the soy stearine degraded slower than the vitamin A in the core. Apparently the antioxidants (BHT+BHA) incorporated into soy stearine intercepted oxygen before it could react with the vitamin. After depletion of the antioxidant, the retinyl palmitate became vulnerable to oxidation. This explains why the vitamin A palmitate dissolved in oil degrades slowly at the beginning and more rapidly later. The fact that the vitamin A degraded more rapidly in the core than in the soy stearine is probably due to encapsulation imperfections. Water and trace minerals could get into the core through



	0 days	15 days	35 days	53 days
□ I-4 = Vitamin A palmitate oil incorporated in coating	100	84	40	9.5
■ II-2 = 40%SS (Vitamin A palmitate + KIO_3 + mannitol + HPMC)	100	63	40	12

FIG. 3. Vitamin A palmitate spray-dried versus dissolved in oil in triple-fortified salt, under high temperature and humidity. Source of iron: ferrous fumarate, 1,000 ppm as Fe. KIO_3, potassium iodate; HPMC, hydroxypropyl methylcellulose; SS, soy stearine

the coat's cratering and attack vitamin A in the core, destroying it more easily than the vitamin A incorporated in the fat.

While bioavailability was not addressed in this work, using a digestible fat for encapsulation should have no effect on the bioavailability of the micronutrients. During cooking the micronutrients will be released, and will behave exactly as the added components: some vitamin A loss will occur during food preparation. Quantitation of this effect is beyond the scope of this work.

Conclusions

Under ambient conditions and 2 months of storage, we obtained the following vitamin A retention: 95% for triple-fortified salt made by two premixes, vitamin A palmitate +FeNaEDTA encapsulated together and potassium iodide (KI) encapsulated separately; and approximately 80% for vitamin A palmitate and potassium iodate (KIO_3) encapsulated together and separately encapsulated FeNaEDTA. At high temperature and humidity, vitamin A was rapidly destroyed. The best vitamin A retention (approximately 60%) after 2 months of storage at 40°C and 100% relative humidity was obtained in salt fortified with vitamin A palmitate granulated with potassium iodate and dextrin and coated with soy stearine, with FeNaEDTA used as the iron source. Premixes containing all three micronutrients in a single particle were less stable than premixes made with iodine and vitamin A in one particle and iron in a separate particle. The types of iron and iodine compounds used for fortification had a significant influence on vitamin A retention. We found that potassium iodate and ferric NaEDTA formed the most stable triple-fortified salt in terms of vitamin A retention.

The type of binder influences vitamin A retention, but the ultimate role in vitamin A stability is played by the quality of the coating. Nonhygroscopic fillers such as mannitol and calcium sulfate dihydrate gave better vitamin A retention than lactose. Spray-dried vitamin A palmitate was more stable than vitamin A palmitate dissolved in oil, but incorporating the vitamin A into the soy stearine provides reasonable vitamin A protection.

The best formulation retained 77.73 % of vitamin A after 2 months of storage at 40°C and 60% relative humidity. Considering that the time salt spends in distribution is typically 2 to 3 months, a substantial (9% to 50%) retention indicates that in an appropriately optimized system reasonable vitamin A retention of 75% or more should be achievable. With process and product optimization, which are beyond the scope of this preliminary survey, we expect to achieve even higher retention, resulting in the need for a smaller overage in a realistic system. Although there have been great increases in the average quality of salt, the effect of salt impurities must be investigated further. On the basis of our experience with double-fortified salt, this is not expected to be an insurmountable hurdle.

Commercial processing will require simple solid mixing equipment in the typical salt plant and central processing of the premix. Although the cost of the encapsulation system itself is only 1 to 3 US cents per kilogram of salt, the added cost of the micronutrient will have a large impact on the cost of the salt, unless the salt is subsidized from savings of current or contemplated supplementation methods.

Acknowledgments

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References

1. Micronutrient Initiative. Vitamin and mineral deficiency: a global progress report—2005. Available at: http://www.micronutrient.org/reports/report.asp?cntry=Full. Accessed 22 June 2006.
2. Jacinto SM, Madan S. Iron deficiency anemia. US Pharmacist 2000; 25:4 http://www.uspharmacist.com/oldformat.asp?url=ce/irondef/default.htm
3. Sommer A, West KP. Vitamin A deficiency: health, survival, and vision. New York: Oxford University Press, 1996.
4. Levin HM, Pollitt E, Galloway R, McGuire J. Micronutrient deficiency disorders. In: Jamison DT, Mosley WH, Measham AR, Bobadilla IL, eds. Disease control priorities in developing countries. New York: Oxford University Press, 1993:421–51.
5. Zimmermann M, Adou P, Torresani T, Zeder C, Hurrell R. Persistence of goiter despite oral iodine supplementation in goitrous children with iron deficiency anemia in Cote d'Ivoire. Am J Clin Nutr 2000;71:88–93.
6. Bloem MV, Wedel M, Van Agtmaal EJ, Speek AJ, Saowakontha S, Schreurs WH. Vitamin A intervention: short term effects of a single, oral, massive dose on iron metabolism. Am J Clin Nutr 1990;51:76–9.
7. Diosady LL, Alberti JO, Venkatesh Mannar MG, Stone TG. Stability of iodine in iodized salt used for correction of iodine-deficiency disorders. Food Nutr Bull 1997; 18:388–96.
8. Diosady LL, Venkatesh Mannar MG. Double fortification of salt with iron and iodine. 8th World Salt Symposium. Vol 2. Amsterdam: Elsevier Science BV, 2000:971–6.
9. Oshinowo T, Diosady L, Yusufali R, Laleye L. Stability of salt double-fortified with ferrous fumarate and potassium iodate or iodide under storage and distribution conditions in Kenya. Food Nutr Bull 2004;25:264–70.
10. Jorg A. Methods of vitamin assay. New York: Wiley, 1985.
11. Lachance PA, Erdman JW Jr, Hou FS-H. Fluorometric determination of vitamin A in foods. J Food Sci 1973;38:447–9.
12. Runge FE, Heger R. Use of microcalorimetry in monitoring stability studies. Example: vitamin A esters. J Agric Food Chem 2000; 48:47–55.
13. Zhuge Q, Klopfenstein CF. Factors affecting storage stability of vitamin A, riboflavin and niacin in a broiler diet premix. Poultry Sci 1986;65:987–94.
14. Ball GFM. Fat-soluble vitamin assays in food analysis. New York: Elsevier Science Publishers, 1989.
15. Halverson AW, Hendrick CM. Effect of trace minerals and other dietary ingredients upon vitamin A stability in stored poultry diets. Poultry Sci 1955;35:175–80.

Nutrition education alone improves dietary practices but not hematologic indices of adolescent girls in Iran

Reza Amani and Maryam Soflaei

Abstract

Background. *Iron-deficiency anemia is the most prevalent nutritional deficiency worldwide. Iron-deficiency anemia has particular negative consequences on women in their childbearing years, and its prevention is a high priority in most health systems.*

Objective. *This interventional study assessed the effect of nutrition education on hematologic indices, iron status, nutritional knowledge, and nutritional practices of high-school girls in Iran.*

Methods. *Sixty healthy 16- to 18-year-old girls were randomly selected from two high schools in the city of Ahvaz and divided into two equally matched groups, one that received nutrition education, and one that did not. The education group received instruction in face-to-face sessions, group discussions, and pamphlets for 2 months. The control group did not receive any information during the study. Hematologic tests, corpuscular indices, and serum ferritin levels were measured at baseline and after 2 months. Food-frequency questionnaires were administered and histories taken, clinical signs of nutritional deficiencies observed, anthropometric measurements taken, nutritional knowledge tested, practices determined, and lifestyle questionnaires administered to all subjects.*

Results. *There were no statistically significant differences in any baseline characteristics between the two groups. Scores for nutritional knowledge and practices of the education group were significantly higher after two months compared with the baseline (31.4 ± 6 vs. 24.3 ± 5.9 points,* $p < .001$*, and 31.2 ± 5 vs. 28.4 ± 5.7 points,* $p < .05$*, respectively). The scores in the control group showed no significant changes from baseline to 2 months. Mean corpuscular volume values were elevated in the education group (*$p < .001$*) but not in the control group. However, in the control group, serum ferritin concentrations showed about a 17% drop at the end of the study (*$p < .004$*). There were no changes in other hematologic, lifestyle, clinical, or anthropometric data compared with baseline after completion of the study in both groups.*

Conclusion. *These findings indicate that nutritional education can improve knowledge of healthy nutrition and lifestyle choices. Focused nutritional education using available resources and correcting current dietary habits in a vulnerable group of young women may result in dietary changes that can ultimately improve iron intake.*

Key words: Female students, hematologic indices, iron status, nutrition education

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Introduction

Iron-deficiency anemia is a common nutritional problem worldwide, particularly for women of reproductive age in developing countries. In pregnant women, severe anemia increases the risk of maternal and fetal morbidity and mortality, and the risk of premature delivery and low birthweight for the infant [1–5]. In adolescent girls, it can have an adverse effect on educational performance, productivity, and well-being. Preventing iron deficiency and increasing iron stores in adolescent girls can improve their iron status in preparation for pregnancy and benefit their current health and well-being [6, 7]. There are reports indicating that improving iron bioavailability in diets may have a greater effect than increasing the total quantity of dietary iron consumed [8–10]. In some developing countries, when access to iron-rich foods and/or heme iron sources is limited, other strategies (e.g., properly aimed nutrition education) are needed [9, 10].

In Iran, official reports show that the prevalence of iron deficiency is highest (39%) in 15- to 19-year-old girls [11]. The reports also indicate that the prevalence of anemia and iron-deficiency anemia in 15- to 49-year-old women are 33.4% and 16.6%, respectively.

There is much evidence supporting the use of iron supplements both daily and weekly for prevention and health strategies [1, 5, 12–14] in adolescent girls. However, limited data are available on the effects of nutrition education alone on the nutritional status of this vulnerable group in the region. Thus, this interventional study was undertaken to explore whether a focused nutrition education campaign could improve the nutritional practices, iron status, and hematologic indices of healthy adolescent girls.

Methods

Study protocol and subjects

This study was a pre-/post-comparison between intervention and control groups conducted on 60 adolescent girls from two separate high schools (30 subjects from each) with similar demographic and socioeconomic characteristics. The high schools were located in the same district but located in different areas to prevent exchange of educational messages. The study was conducted in the winter of 2004 when all food groups were locally available. Sixty healthy 16- to 18-year-old girls were randomly selected from the class lists and their parents' written consent obtained. The inclusion criteria were that the subjects had to be healthy, nonanemic adolescent girls 16 to 18 years of age from the middle socioeconomic classes based on their family residency, number of rooms in the house, and parental characteristics, such as educational level and employment. Data on these variables were collected by basic socioeconomic questionnaires.

Girls were excluded who were ill or anemic, were taking iron or other nutritional supplements, or whose parents withheld permission. The education group received nutritional education on dietary sources of iron, iron availability, and the signs and consequences of iron deficiency and anemia via face-to-face group discussion sessions and simple pamphlets; the control group did not receive any nutritional education during the 2-month study period. The study groups had no contact with each other. Subjects were asked to follow their usual lifestyle patterns and were informed about the purpose of the study prior to the start. Fasting blood samples (5 mL) were taken from each subject pre- and postintervention. The study protocol was approved by the University Medical Ethics Committee.

Variables and questionnaires

Questionnaires were used to collect information on nutritional knowledge and practice. Anthropometric measurements, including weight, height, and body-mass index (BMI) were taken, and information on sleep and exercise patterns and past medical history, including previous history of disease and medication use, was obtained through questionnaires. Semiquantitative food-frequency questionnaires (FFQs) were also completed. Subjects' weights and heights were measured with a digital scale (Soehen, Germany) and a nonstretchable wall meter. The body-mass index was calculated as the weight in kilograms divided by the square of the height in meters. A general practitioner examined the girls for paleness and other signs of nutritional deficiencies. Medical histories, physical signs, and socioeconomic questionnaires were used to explore any differences between the study groups. Percent body fat was measured by the bioelectrical impedance analysis method with an Omron BF-302 apparatus (Matsusaka Co. Ltd., Japan). All of these values were recorded at baseline and at 2 months postintervention. The questionnaires had been validated by previous national epidemiologic studies on anemia prevalence conducted by the Ministry of Health in collaboration with the National Nutrition Institute in different parts of the country.

Data scoring

Data collected from FFQs were scored on the basis of the US Food Guide Pyramid [15] in which five main food groups received scores of 0 to 5 according to the frequency of their consumption. For example, in the case of vegetables, no consumption was scored as 0 points and three to five servings per day was scored as 5 points.

Questions on students' nutritional knowledge (food groups, nutrients, and anemia) and lifestyle patterns (diet, sleep, and exercise) were also scored. Both categories had 10 questions with options to be chosen, and 0 to 5 points were assigned to each option so that the maximum obtainable score was 50.

Laboratory measurements

Complete blood counts were performed, and corpuscular indices and serum ferritin levels were measured by a hematologic cell counter Sysmex K-1000 apparatus (TOA Medical Electronics Co. Ltd., Kobe, Japan) and the ELISA method (SPECTRA III, Orgentec Diagnostika GmbH, Mainz, Germany) [16], respectively. The lower detection limit for ferritin was determined as 5 ng/mL, and the intra- and interassay corpuscular volumes were 3.4 and 1.7 ng/mL, respectively. Hematologic interpretation was based on WHO criteria [17].

Statistical analysis

Independent and paired *t*-tests were performed to explore any difference between baseline and pre- and postintervention findings, respectively, and the normality of the distribution of the variables was confirmed by the Kolmogorov-Smirnov test. SPSS software, version 11.5, was used for data analysis. The significance level for data was $p < .05$.

Results

Table 1 shows the baseline anthropometric indices for the two study groups; there are no significant differences between them. The mean score for nutritional knowledge of the education group significantly increased after 2 months compared with baseline (31.4 ± 6 vs. 24.3 ± 5.9; $p < .001$), but there was no improvement in the control group (**table 2**). Both groups showed no change in their lifestyle patterns during the study period (**table 3**). There was a significant increment in mean corpuscular volume (MCV) levels in the education group ($p < .001$), and at the same time, serum ferritin concentrations dropped about 17% in the control group ($p = .004$; **table 4**). However, no significant changes were seen in hemoglobin and serum ferritin levels of the education group. **Table 5** shows that food-frequency scores were elevated in the education group ($p < .05$) but the control group had a nonsignificant fall in its scores after the campaign ($p < .1$).

Discussion

Iron deficiency and anemia are among the most important remaining nutritional deficiencies and health problems of public health significance worldwide, mainly in developing countries. Anemia impairs the cognitive development of children from infancy through adolescence by up to 5 to 10 intelligence quotient (IQ) points, and this impairment is permanent [17, 18]. Up to 30% impairment of physical work capacity and performance is reported in anemic men and women, depending on the severity of their anemia [17–20]. Adolescent girls are especially susceptible to iron deficiency because of their poor dietary intake in conjunction with high iron requirements related to rapid growth and menstrual blood loss [10]. Even in the United States, up to 11% of adolescent girls are iron deficient [21].

This intervention resulted in a marked change in nutritional knowledge and scores of food-group consumption of adolescent girls participating in the educational campaign. Moreover, the mean corpuscular volume of the education group showed a significant postintervention improvement but it was within normal ranges. On the other hand, the control group had a fall in serum ferritin concentration after 2 months. Both groups showed no significant changes in hemoglobin levels, which may be due to the short duration and relatively small sample size of the study. Creed-Kanashiro et al., in their interventional study on 12- to 17.9-year-old old Peruvian girls, showed that after an educational campaign was implemented for 9 months, total, absorbable, and heme iron intake significantly increased in the education group. Moreover,

TABLE 1. Baseline anthropometric indices of the two study groups (mean ± SD) [a]

Group	Height (cm)	Weight (kg)	% body fat
Education (n = 30)	160.2 ± 5.5	54.3 ± 9.8	23.4 ± 5.3
Control (n = 30)	160.6 ± 6	57.2 ± 10	25.3 ± 4.5

a. There were no statistically significant differences in anthropometric measurements between the groups.

TABLE 2. Nutritional knowledge scores of the two study groups at baseline and after 2 months of education (mean ± SD)

Group	Before	After	p
Education (n = 30)	24.3 ± 5.9	31.4 ± 6	< .001
Control (n = 30)	22.6 ± 10.2	23.3 ± 6.9	.3

TABLE 3. Lifestyle scores of the two study groups at baseline and after 2 months of education (mean ± SD)

Group	Before	After	p
Education (n = 30)	20.6 ± 5.6	20.7 ± 6	.8
Control (n = 30)	21.5 ± 4.4	21.2 ± 4.9	.8

TABLE 5. Semiquantitative food-frequency scores of the two study groups at baseline and after 2 months of education (mean ± SD)

Group	Before	After	p
Education (n = 30)	28.4 ± 5.7	31.2 ± 5	< .05
Control (n = 30)	31.2 ± 8	29 ± 6.5	< .1

TABLE 4. Hematologic indices of the two study groups at baseline and after 2 months of education (mean ± SD)

	Education group (n = 30)		Control group (n = 30)	
Index	Before	After	Before	After
Hemoglobin (g/dL)	13.8 ± 0.9	13.5 ± 0.9	13.5 ± 0.7	13.4 ± 0.9
Mean corpuscular volume (fL)	82.6 ± 4.6	86.9 ± 4.9*	85.4 ± 6.4	85.9 ± 4.4
Serum ferritin (ng/ml)	18.5 ± 14.4	15.4 ± 8.3	17.8 ± 11.7	14.8 ± 9.1**

* $p < .001$ compared with baseline.

** $p = .004$ compared with baseline.

total daily ascorbic acid intake and nutritional knowledge showed a significant improvement in the intervention group [10]. In our study, the groups were similar in their socioeconomic, lifestyle, and anthropometric features. Furthermore, this study showed that dietary change to improve iron intake is possible in this sample of adolescent girls. A multidietary strategy using a feasible educational program combined with identifying and promoting the best choices of iron-rich foods is required to increase consumption of animal sources of iron and vegetables with iron absorption enhancers such as vitamin C [8, 9]. These strategies are potentially applicable in our region, because rich sources of vitamin C, such as vegetables and fresh fruits, are available throughout the year.

It was also observed that basic nutritional knowledge was inadequate in young girls, and our previous findings have emphasized this lack [22]. Malhotra and Passi also showed that a large majority of Indian adolescent and young girls had inadequate knowledge of health and nutritional issues. They indicated that 93.4% of the subjects had inadequate iron intake and 93.2% of them were anemic [23]. Iron supplementation in 16- to 20-year-old Indian college girls was associated with significant increases in body weight, body-mass index, mid-upper-arm circumference, and body fat [13]. Although there is much evidence supporting the use of iron supplementation in vulnerable groups, findings on the effects of nutrition education without supplementation and/or food fortification are lacking, especially in regions in which both iron-rich sources (e.g., pulses) and folate- and vitamin C-rich sources (e.g., fresh fruits and vegetables) are available.

In conclusion, although this research was a pilot study with a limited number of subjects conducted in a short period of time, the results were encouraging. We suggest that the education program and materials used captured the girls' interest and stimulated their motivation to influence their health, nutrition, and diet. The potential of applying this experience through high schools and other organizations reaching young girls provides a feasible opportunity to attain the high-priority health goals.

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References

1. Gillespie SR. Major Issues in the control of iron deficiency. Ottawa, Canada: Micronutrient Initiative and UNICEF, 1998.
2. Murphy JF, O'Riordam J, Pearson JF. Relation of hemoglobin levels in first and second trimesters to outcome of pregnancy. Lancet 1986;1: 992–4.
3. WHO. Official Records. National strategies for prevention and control of micronutrient malnutrition. WHO 45 /1992/REC/I, Annex 8, P. 195. Geneva: WHO, 1992.
4. Scrimshaw NS. Functional significance of iron deficiency: an overview. In: Enwonwu CO, ed. Functional significance of iron deficiency. Nashville, Tenn, USA: Mehary Medical College, 1990:1–3.
5. De Maeyer EM, Dallman M, Curney P, et al. Preventing and controlling iron deficiency anemia through primary health care: A guide for health administrators and programme managers. Geneva: WHO, 1989.
6. WHO. The prevalence of anemia in women: a tabulation of available information. Document WHO/ MCH/ MSM/ 92.2. Geneva: WHO, 1992.
7. Zavaleta N, Respicio G, Garcia T. Efficacy and acceptability of two iron supplementation schedules in adolescent school girls in Lima, Peru. J Nutr 2000;130 (2S suppl):462S–4S.
8. Layrisse M, Garcia-Casal MN. Strategies for the prevention of iron deficiency through foods in the household. Nutr Rev 1997;55:233–9.
9. Tseng M, Chakraborty H, Robinson DT, Mendez M, Kohlmeier L. Adjustment of iron intake for dietary enhancers and inhibitors in population studies: bioavailable iron in rural and urban residing Russian women and children. J Nutr 1997;127:1456–68.
10. Creed-Kanashiro HM, Uribe TG, Bartolini RM, Fukumoto MN, Lopez TT, Zavaleta NM, Bentley ME. Improving dietary intake to prevent anemia in adolescent girls through community kitchens in a periurban population of Lima, Peru. J Nutr 2000;130(2S suppl):459S–61S.
11. Sheikholeslam R, Abdollahi Z, Jamshid-Beigi E. et al. Prevalence of iron deficiency, anemia, and iron deficiency anemia in women of child-bearing age (15–49 y) in urban and rural areas of Iran. Ministry of Health published records, winter 2003.
12. Bruner AB, Joffe A, Duggan AK, Casella JF, Brandt J. Randomised study of cognitive effects of iron supplementation in non-anaemic iron-deficient adolescent girls. Lancet 1996; 348(9033):992–6.
13. Mann SK, Kaur S, Bains K. Iron and energy supplementation improves the physical work capacity of female college students. Food Nutr Bull 2002;23:57–64.
14. Tee ES, Kandiah M, Awin N, Chong SM, Satgunasingam N, Kamarudin L, Milani S, Dugdale AE, Viteri FE. School-administered weekly iron-folate supplements improve hemoglobin and ferritin concentrations in Malaysian adolescent girls. Am J Clin Nutr 1999;69;1249–56.
15. US Department of Agriculture. Food and Nutrition

Information Center. Food Guide Pyramid. Available at: http://www.nal.usda.gov/fnic/Fpyr/pyramid.html. Accessed 28 June 2006.

16. Dawson DW, Fish DI, Shackleton P. The accuracy and clinical interpretation of serum ferritin assays. Clin Lab Haematol 1992; 14:47–52.
17. WHO. Indicators and strategies for iron deficiency and anemia programmes. (Based on a WHO/UNICEF/ UNU consultation). Geneva: WHO, 1995.
18. Halterman JS, Kaczorowski JM, Aligne CA, Auinger P, Szilagyi PG. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. Pediatrics 2001;107:1381–6.
19. Booth IW, Aukett MA. Iron deficiency anaemia in infancy and early childhood. Arch Dis Child 1997;76:549–53.
20. Patterson AJ, Brown WJ, Roberts DC, Seldon MR. Dietary treatment of iron deficiency in women of child-bearing age. Am J Clin Nutr 2001;74:650–6.
21. Looker AC, Dallman PR, Carroll MD, Gunter EW, Johnson CL. Prevalence of iron deficiency in the United States. JAMA 1997;277:973–6.
22. Amani R. Evaluation of nutritional-related lifestyle pattern of female university students in dormitories. 6th International Epidemiology Association Scientific Meeting in Eastern Mediterranean Region, Ahwaz, Iran, December 9–11, 2003.
23. Malhotra A, Passi SJ. Nutrition and health status of rural adolescent girls in selected ICDS blocks of Delhi and Rajasthan. Asia Pac J Clin Nutr 2004;13(suppl):S134.

Commentary

Quality protein maize

Nevin S. Scrimshaw

It has been many years since the first demonstration that young children consuming equal amounts of protein at requirement levels from milk or maize with the opaque-2 gene had the same nitrogen retention [1]. The physical and agronomic characteristics of maize with the opaque-2 gene, renamed quality protein maize (QPM), have been steadily improved.

Further studies have confirmed that when protein and energy requirements are met, nitrogen retention is similar for QPM and milk, meat, and eggs [2]. This is because, unlike ordinary maize, which is deficient in the essential amino acids lysine and tryptophan, QPM has adequate proportions of both. QPM studies have been summarized in a National Academy of Science publication [3] and in two books [4, 5].

Even though the yields of QPM are as high as those of ordinary maize, and its use for feeding nonruminants decreases the need for protein concentrates such as oilseed or fish meal, QPM has been slow to be adopted. Its use for human consumption in populations that are highly dependent on maize protein has been particularly disappointing. This is due in part to resistance to change, but more to the decrease in interest in protein quality beginning in the 1970s.

The change began with the meeting of the Food and Agriculture Organization/World Health Organization (FAO/WHO) Ad Hoc Committee on Energy and Protein Requirements in Rome in 1971 [6]. The lower level of protein this committee proposed as adequate for adults led to the conclusion that energy and not protein was limiting in the diets of developing countries. This nearly ended the QPM program at the International Maize and Wheat Improvement Center in Mexico (CIMMYT) [7]. On the basis of extensive new research, it was subsequently recognized that the 1971 recommendation was erroneously low. The new value confirmed the pre-1971 conclusion that protein was inadequate in the predominantly cereal diets of most developing countries worldwide [8]. A 1985 FAO/WHO/UNU expert group [9] recommended an increase of nearly one-third over the 1971 value. Unfortunately, the damage to the understanding of nutritionists and economists continues, and too often the importance of protein quality in the diets of developing-country populations is not recognized.

QPM is now being grown on an increasing scale in a few African and Latin American countries. The discovery of the opaque-2 gene and its incorporation into high-yielding maize varieties was an important achievement and occurred before the availability of modern genetic modification techniques that might have speeded the process. The developers of QPM, Dr. Evangelina Villegas and Dr. Surinder K. Vasal, received the World Food Prize for this achievement in 2000. QPM varieties can make a major contribution to the protein adequacy of maize diets wherever maize is the major dietary protein source for local populations.

A 13-page 2002 research report [10] on local infant feeding in Ghana is a valuable and practical demonstration of the value of QPM in the feeding of poorly nourished children in populations without the economic resources to purchase milk and other animal protein sources to feed themselves and their children. It describes four studies that provide compelling evidence for advocating the introduction of QPM. Where it is used in gruels for the complementary feeding of infants and young children, barley malt can be added to the maize flour. The malt provides an enzyme that liquefies the cereal gruel prepared from the maize so that the young children can consume enough to meet their protein needs.*

Much greater efforts should be devoted to promoting the production and use of QPM by populations dependent on maize as the staple in their own diets as well as their nonruminant animals.

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References

1. Bressani R, Alvarado J, Viteri F. Evaluación, en niños, de la calidad de la proteina del maiz, opaco-2. Arch Latinoam Nutr 1969;19:129–40.
2. Young VR, Ozalp I, Cholakos BV, Scrimshaw NS. Protein value of Colombian opaque-2 corn for young adult men. J Nutr 1971;101:1475–81.
3. Quality Protein Maize: Report of Advisory Committee on Technology Innovation; Board on Science and Technology for International Development; National Research Council. Washington, DC: National Academy Press, 1988.
4. Mertz E, ed. Quality protein maize. St. Paul, Minn, USA. American Association of Cereal Chemists (AACC), 1992.
5. Larkin B, Mertz E, eds. Quality Protein Maize: 1964–1994. Proceedings of the International Symposium on Quality Protein Maize, Sete Lagoas, Brazil, December 1–3, 1994.
6. Food and Agriculture Organization/World Health Organization. Energy and Protein Requirements. Report of a joint FAO/WHO Ad Hoc Expert Committee (Rome, 1971). WHO Technical Report Series No. 522. Geneva, 1973.
7. Scrimshaw NS. Strengths and weakness of the committee approach. An analysis of past and present recommended dietary allowances for protein in health and disease. N Engl J Med 1976;294:136–42, 198–203.
8. Young VR, Pellett P. Plant proteins in relation to human protein and amino acid nutrition. Am J Clin Nutr 1994;59(5 suppl):1203S–12S.
9. Food and Agriculture Organization/World Health Organization/United Nations University. Energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation (Rome, 1981). WHO Technical Report Series No. 724. Geneva, 1985.
10. Akuamoa-Boateng A. Quality protein maize: Infant feeding trials in Ghana. Three studies comparing quality protein maize (QPM) koko and normal maize (NM) koko. Ghana Health Service. Kumasi, Ghana, 2002.

Mysore Declaration: Capacity strengthening in nutrition

Editorial commentary

A group of more than 70 international nutrition scientists and leaders met in 2006 for an international symposium to discuss current and emerging needs for capacity building in the field of public nutrition at the Central Food Technological Research Institute (CFTRI) in Mysore, India. Dr. V. Prakash, Director, CFTRI, was the organizing committee chair for this meeting. The presentations and discussions concluded with the group reviewing and approving the "Mysore Declaration: Capacity Strengthening in Nutrition," which follows here.

The Mysore Declaration outlines major challenges and calls upon international and bilateral agencies, national governments, nongovernmental organizations, and the private sector to reposition nutrition as central to national development and increase the investments in nutrition at the global, national, and international levels to address the double burden of malnutrition with a single agenda.

All participants strongly supported the need to improve the capacity of developing country institutions to overcome the many nutrition problems that are holding back social and economic development. However, there was much concern for the frequency with which some of the best trained and productive nutrition scientists are recruited by international agencies and organizations and the private sector for posts outside their own countries. This often constrains national efforts at capacity building in nutrition and is disheartening to organizations attempting to provide high quality advanced training for developing-country nutrition scientists.

The Declaration urges that organizations, agencies, and companies recruiting in developing countries include policies that mitigate the depletion of the limited pool of trained national nutrition professionals. The Mysore Declaration urges that a national capacity development fund be set up by all stakeholders and dedicated specifically to developing and strengthening individual and institutional capacities in food and nutrition in developing countries. Recognizing that these agencies and private companies need competent people from developing countries, this may well provide an extremely helpful contribution to food and nutrition capacity building in these countries. An amount of 2% of program costs was suggested but considered too arbitrary to be incorporated in the final Declaration.

In its penultimate paragraphs, the Declaration urges all sectors of society, including UN organizations, bilateral agencies, international NGOs, and other donor agencies, national governments, civil society, and the private sector, especially the food processing and food services industries, to work together to position nutrition more centrally in terms of national development and increase related investments at all levels. All of these stakeholders will gain much from improved national capacity in food and nutrition. The Declaration also urges civil society to hold governments responsible at all levels for effective implementation of measures for capacity development in food and nutrition.

The Mysore Declaration should be widely circulated, taken to heart, and acted upon by all stakeholders in the improvement of food and nutrition capacity of developing countries. A plan of action proposed to accompany the Mysore Declaration is currently being prepared by a drafting group from organizations represented in the Symposium. It will be presented in a future issue of the *Bulletin*.

—Nevin S. Scrimshaw

We from Africa, Asia, Europe, and the Americas, met as participants in a symposium, "Building Leadership Skills in Food and Nutrition Essential for National Development," on 23–25 June 2006, organized by the Central Food Technological Research Institute (CFTRI) at Mysore, India under the auspices of the United Nations University (UNU), Capacity Strengthening in Nutrition in Asia (CASNA), International Union of Nutritional Sciences (IUNS), International Nutrition Foundation (INF), Tufts University, and UNICEF, with support of the Government of India, declare as follows:

The nature of the present global food and nutrition problems.

We live in a world of great inequity in terms of access to food and existing nutrition conditions both within and among countries. This is not only morally unacceptable but also has enormous costs in terms of human lives, affecting social and economic development. In this world of plenty, more than 800 million people are undernourished and about 170 million infants and young children are underweight. More than five million children die each year as a result of under-nutrition. Furthermore, billions of people suffer from vitamin and mineral deficiencies, especially of iron, iodine, vitamin A, and zinc. Good nutrition is also constrained by inadequate safe drinking water and sanitation.

At the same time, obesity and other nutrition related chronic disease are becoming a serious problem, even in low income countries. More than one billion adults worldwide are overweight, of whom 300 million are obese. These issues are often rooted in poverty and co-exist in communities, some in the same households. While under-nutrition kills in early life, it also leads to a high risk of chronic diseases and death later in life. This is the double burden of malnutrition, with common causes: inadequate fetal, infant, and young child nutrition compounded by exposure to energy dense, nutrient poor foods, and limited physical activity.

The greatest opportunity for effective interventions comes from pre-pregnancy to 24 months of a child's age. Schools also provide a natural setting for effective interventions for older children and the promotion of adequate nutrition to future mothers. Malnutrition, in all its forms, amounts to an intolerable burden, not only on national health systems, but on the entire cultural, social and economic fabric of nations, and is the greatest impediment to the fulfillment of human potential.

Despite the impact of malnutrition in all its forms on mortality, morbidity, and national economies, only 1.8% of the total resources for health-related development assistance are allocated to nutrition activities. Of the World Bank's total assistance to developing countries, only 0.7% is for nutrition and food security, and at country level, even less. Adequate food is a human right and good nutrition is essential to achieve the aims of the Millennium Declaration and the Millennium Development Goals. Collaboration among the health, agriculture and education sectors is particularly important in capacity building. Without progress in addressing malnutrition, these goals will not be realized.

Building and strengthening capacity to address global food and nutrition problems is essential to a sustainable solution.

We have come together to place capacity strengthening and development to improve nutrition at the center of the solution to this global problem.

We urge UN organizations, bilateral agencies, international NGOs, and other donor agencies:

To act individually and together through the UN SCN to prioritize investments in the advanced training of human resource and institutional capacities required to prevent and control all forms of malnutrition throughout life. This will contribute substantially to the achievement of the Millennium Development Goals, preventing death and disability while promoting health and well being.

To include in their human resource recruitment, policies that mitigate the depletion of the limited pool of trained professionals. They are critical for sustaining national and regional actions in food and nutrition. A Nutrition Capacity Development Fund should be set up by all stakeholders and dedicated specifically to developing and strengthening individual and institutional capacities in food and nutrition.

This could be achieved by requiring that every project include two percent in its budget towards this fund. These resources could be disbursed with input of development partners within a regional and sub regional context. If professionals are hired from a developing country, UN and other development agencies should compensate the fund for these costs. These resources will serve to train one or more replacements.

In addition, every project should have an inbuilt component of capacity building that would be measurable at the end of the project.

We recommend that national governments:

Commit to establishing or strengthening institutions that can contribute effectively to the solution of food and nutrition problems through research, training and outreach programs. These institutions should be adequately funded and have policies that attract young leaders in this field, promote career development of staff, and support and encourage those who actively contribute.

Commit, in accordance with the UNU/IUNS model, to strengthening human resources capacities through a national system of advanced training to address food and nutrition problems. This encompasses especially training at all levels including the community, community leaders, program implementers, researchers/ teachers/ program planners and policy makers to the highest level. Each level will acquire new knowledge, skills, attitudes, and commitment in nutrition science, communications and advocacy, social marketing, industrial research and development, policy and planning. *(add reference)*

We propose networking with civil society, especially community based non-governmental organizations (NGOs) to:

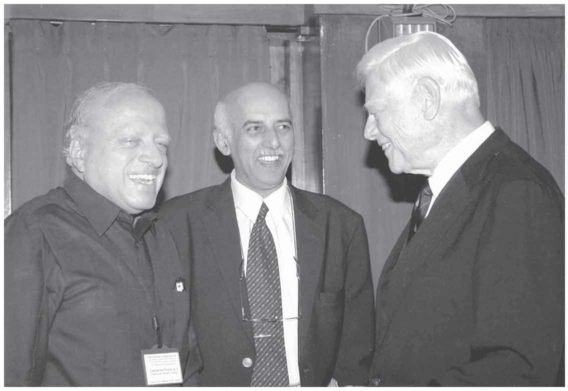
Advocate for the building and strengthening of national and regional capacity to address food and nutrition problems in accordance with local needs.

Adopt policies that promote, support and sustain the capacities of individuals and institutions necessary to address food and nutrition problems.

Hold governments at all levels to be responsible for effective implementation with regard to capacity development in food and nutrition.

We call on the private sector, especially the food processing industries and food services to:

Mitigate the depletion of the limited pool of trained professionals, critical for sustained national and regional actions in food and nutrition by participating in the proposed Nutrition Capacity Development Fund and contribute to its objectives by sharing information, and research expertise for capacity building and education.



Left to right: Professor M. S. Swaminathan, President of the M. S. Swaminathan Foundation; Dr. V. Prakash, Director of the Central Food Technology Research Institute (CFTRI) and organizer of the symposium; and Dr. Nevin S. Scrimshaw, the keynote speaker at the symposium. Both Dr. Swaminathan and Dr. Scrimshaw are former World Food Prize laureates.

Support development of national and regional capacities to address food and nutrition problems, including responsible marketing practices and the development of healthier foods and beverages that will contribute to good nutrition throughout life.

We will work together to:

Reposition nutrition as central to national development.

Increase the investments in nutrition at global, national and local levels to address the double burden of malnutrition with a single agenda.

We present at this meeting:

Pledge ourselves to all of the above and to continue to work together, as members of the UNU/IUNS/INF Regional Task Forces on Capacity Development in Nutrition in consultation with UN, international and bilateral agencies, national governments, private sector, NGOs, civil society and other constituencies.

Book reviews

Nevin S. Scrimshaw

Childhood obesity: Contemporary issues. Edited by N. Cameron, N. G. Norgan, and G. T. H. Ellison. CRC Press/Taylor & Francis Group, Boca Raton, Fla., USA, 2005. (ISBN 0-8493-2857-8) 304 pages, hardcover. US$89.95.

The alarming rise in the prevalence of obesity and the increased morbidity and mortality from chronic disease is seriously damaging to the populations of the industrialized countries. Moreover, obesity is spreading to the more affluent segments of the populations of developing countries before they overcome undernutrition among their poor, so ultimately they must face a double burden of disease. Now there is a mounting realization that there is also a serious, rapidly growing epidemic of childhood obesity with adverse health consequences, especially diabetes, in evidence.

In the United States there is a massive effort, led by the Centers for Disease Control and Prevention, to combat the steadily worsening epidemic of childhood obesity. Attention is being given to the huge consumption of sweetened, carbonated beverages and calorie-dense snack foods. There is a growing movement to ban the sale of such foods in schools. Some European countries have begun their own programs, and the problem is appearing in many developing countries as well. It is useful to have a book on childhood obesity written almost entirely by British authors. It complements the accumulating U.S. literature on the implications and management of this health crisis.

The initial chapters consider the assessment and prevalence of the problem globally, the health consequences of childhood obesity, social and self-perceptions of obesity, and the parental perspective. The six chapters of Part II deal with the relative roles of biological and social processes in the etiology of childhood obesity. The final four chapters focus on prevention. The last section begins with a description of some innovative approaches in the United Kingdom that will be of interest to health workers in other countries. In the final chapter, the barriers to, and the facilitators of, healthy eating are subjected to a systematic review. It establishes, first, that the majority of food products advertised for children are high in sugar, fat and, salt; and second, that this promotional activity does affect what foods children prefer, buy, or ask their parents to buy. It concludes that "we cannot expect children to make healthy choices in an environment that promotes the opposite." The book supports the conclusions of those who believe that the marketing of foods to children must be changed and healthier foods be made available for them.

The book does have a serious weakness. It does not sufficiently emphasize other aspects of lifestyle beyond diet. The focus is almost entirely on food intake, with only one chapter that mentions the role of physical activity in any depth.

The impact of maternal nutrition on the offspring (Nestlé Nutrition Workshop Series). Edited by Gerard Hornstra, Ricardo Uauy, and Xiaoguang Yang. S. Karger, Basel, Switzerland, 2005. (ISBN 3-8055-7780-X) 256 pages, hardcover. US$207.25.

There is no more heart-rending problem in human nutrition than the permanent damage done to the physical and mental development of children by malnutrition in utero and in infancy.

Most common is the decrease in intelligent quotient (IQ) associated with iodine deficiency that can be so easily prevented by iodized salt and a similar effect from iron deficiency in infancy. The maternal malnutrition that leads to low birthweight also has far-reaching consequences, because it leads to earlier and more severe iron deficiency, increases nutritionally caused stunting in the preschool child at an early age, and can also permanently impair physical and mental development.

Instead of focusing only on these well-known and well-documented effects of maternal malnutrition on the offspring, this report of a Nestlé Foundation Workshop held in Beijing in 2004 explores the topic in greater breadth and depth. Early chapters focus on transgenerational effects, consequences of energy deficiency in pregnancy, effects of nutrition on placental function, essential fatty acids during pregnancy and their long-term effects, and the effects of maternal malnutrition on infections in later life. There is a chapter on nutrient-induced hyperinsulinemia and metabolic programming in pregnancy and a related chapter on size and body composition at birth and the risk of type 2 diabetes.

Two of the chapters deal with the relationship between obesity and adverse pregnancy outcomes and with the special problems of nutrition in the pregnancy of teenagers. A chapter on dietary interventions during pregnancy and allergic disease in the offspring is followed by discussions of future challenges to nutrition and of pregnancy and lactation. The chapters are authored or coauthored by leading global authorities and are well referenced. This is an excellent supplement to textbook descriptions of the immediate and long-term effects of malnutrition during pregnancy and lactation on the offspring.

Medicinal spices: A handbook of culinary herbs, spices, spice mixtures and their essential oils. By Eberhard Teuscher. CRC Press/Taylor & Francis Group, Boca Raton, Fla., USA, 2005. (ISBN 0-8493-1962-5) 459 pages, hardcover. US$149.95.

The foreword notes that herbs and spices are among the most important anti-inflammatory, antioxidant, antiaging, and immune-boosting foods, with the capacity to improve and even extend our lives. *Medicinal Spices* not only covers their culinary and medicinal potential, but also offers information on their cultivation, production, constituents, organoleptic characteristics, and biological action, as well as their potential toxicity.

This is an English translation of a massive German compendium and is divided into two parts: a general section and individual monographs on 82 herbs and spices, each identified by a large color plate, plus a section on spice mixtures and other seasonings. The general section is filled with related information focusing on the constituents, sensory effects, pharmacology, medicinal use, preservative qualities, and uses of herbs and spices. It even includes chapters on cultivation, breeding, contamination, culinary uses, and food and drug regulations.

A list is provided of 111 books and monographs, most of them in German, which are used as general references, in addition to the reference lists at the end of each chapter. Although not many readers are likely to own this large and attractive volume, it should be in the libraries of institutions that include herbs and spices in their educational and/or research activities.

Nutritional health: Strategies for disease prevention. 2nd edition. Edited by Norman J. Temple, Ted Wilson, and David R. Jacobs, Jr. Humana Press, Totowa, N.J., USA, 2006. (ISBN 1-58829-454-4) 465 pages, hardcover. US$99.50.

This second edition of a valuable reference text is addressed to those who need up-to-date information on recent advances in human nutrition to apply to the development and implementation of nutrition-related health interventions. It is intended to complement more comprehensive texts by discussing recent thinking and discoveries that have the greatest capacity to improve human health and welfare. The 26 individually authored and extensively referenced chapters do this very well.

The list of topics covered includes the use of epidemiology, the nutrition transition, diabetes, lipids, hypertension, cardiovascular disease, cancer, phytochemicals, alcohol consumption, obesity, chronic disease in the elderly, global dietary guidelines, exercise and sports, novel foods, functional foods, and biotechnology to improve foods. Even the political influence of the food industry, population nutrition, health promotion, and government nutrition policies receive attention. The roles of nutritional anthropology and of the Internet have their own chapters.

It is hard to believe that as recently as 30 years ago few people were aware of the power of nutrition to influence such chronic diseases as cancer and heart disease, permanently affect the intelligence of children, and alter the incidence and severity of acute and chronic infections. This book goes far beyond descriptions of nutrition issues and problems by focusing on strategies for the prevention of a wide range of nutrition-related health problems. This gives it special value for anyone involved in the prevention of nutrition-related disorders. Adequacy of the evidence and sources of bias receive attention throughout. It is much better as a textbook for courses in nutrition for future health professionals than one concentrated mainly on descriptions of nutritional problems.

Probiotic dairy products. Edited by A. Y. Tamime. Blackwell Publishers, Ames, Ia., USA, 2006. (ISBN 1-4051-2124-6) 232 pages, hardcover. US$169.99.

The gastrointestinal tract and its extraordinarily complex microbiota constitute a single organ. It is the most diverse and metabolically active organ in the human body. We are continually learning more about the capacity of food components to influence the gut in ways that are favorable or unfavorable for health. One result has been an explosion of interest in the potential health benefits of probiotics and prebiotics in functional foods. This volume, authoritatively edited for the British Society of Dairy Technology, reviews the latest scientific developments with regard to aspects of fermented milk products and their ingredients. It arrives at the conclusion that probiotic functional foods can best be expected to reduce health-care costs and absenteeism from intestinal disease, as well as improving quality of life.

The first chapter reviews the multiple kinds of influence on gut flora and the microorganisms that have been found to have probiotic activity. The second chapter describes the genomic sequencing that has been completed for 13 organisms and is in progress for 28 more. Subsequent chapters describe progress in the production and viability of probiotic organisms in dairy products, current legislation affecting the control of probiotic products and prebiotic ingredients, and the development of starter cultures. The health claims being made for probiotics are discussed in detail and evaluated. Final chapters discuss the production of vitamins, exopolysaccharides, and bacteriocins by probiotic bacteria, as well as the future for probiotic dairy products. Each chapter is exceptionally well referenced.

News and notes

IAEA Nobel Peace Prize Fund Schools for Nutrition

The International Atomic Energy Agency (IAEA) Nobel Cancer and Nutrition Fund was created to use the Agency's share of the 2005 Nobel Peace Prize for capacity-building in the priority areas of cancer and childhood nutrition. The aim for nutrition is to contribute to capacity-building in member states through fellowship training in the use of stable isotope techniques in the development and monitoring of nutrition programs to combat malnutrition, particularly in infants and children.

The training will be directed at young professionals, especially women, from developing countries. In addition, five-day regional events, the IAEA Nobel Peace Prize Fund Schools for Nutrition, will be held in Africa, Asia and the Pacific, and Latin America. Participants will include policy makers and professionals with relevant backgrounds in nutrition. The theme of such events will be specific to each host region.

In Asia and the Pacific the theme will be "focus on interventions to combat undernutrition during early life," aiming at developing effective nutrition interventions for young women before they become pregnant as well as infants and young children during the first 2 years of life. In Africa the theme will be "integrating nutrition into the management of HIV/AIDS," addressing issues related to nutrition and HIV/AIDS during early life. In Latin America the theme will be "combating the double burden of malnutrition." Changes in diet and lifestyle have resulted in increased obesity, which at the same time coexists with undernutrition.

The IAEA Nobel Peace Prize Fund Schools for Nutrition are planned for October and November 2006. More detailed information about the exact dates and the venues will be available soon.

Nominations of candidates for fellowship training and participation in the IAEA Nobel Peace Prize Fund Schools for Nutrition may be submitted on the standard IAEA application forms (http://www-tc.iaea.org/tcweb/participation/asfelloworvisitor/default.asp for fellowship training and http://www-tc.iaea.org/tcweb/participation/inmeetings/default.asp for the Schools, respectively), which should be sent to the IAEA through official channels.

For more information, please contact Lena Davidsson at L.Davidsson@IAEA.ORG.

IFPRI Issue Brief No. 44: Gender and development: Bridging the gap between research and action

Practitioners may ask why they should address gender issues in development. Aside from the obvious answer—that gender equality is a basic human right and in that sense is integral to development—many disparities in development outcomes stem from gender differences. Although practitioners are often knowledgeable about general development and technical issues, many lack the understanding and resources necessary to effectively integrate gender issues into specific projects and public policy. Further, many practitioners are not convinced of the importance of gender issues, or they may find it difficult to navigate approaches in the context of development.

Gender considerations can affect the allocation, targeting, and control of resources; hence, an understanding of how resources are allocated within households can profoundly affect policies associated with the design and implementation of development projects. For specific projects, incorporating research findings can increase their effectiveness.

Recent research undertaken by the International Food Policy Research Institute (IFPRI) provides empirical evidence on the effects of gender and intrahousehold issues on development intervention outcomes, as well as specific guidance on how to incorporate research findings effectively into development projects and policy instruments. The challenge is to bridge the gap between research and action. It is vitally important—regardless of whether gender issues are taken into account—that programs and policy instruments be backed by rigorous research. A recently published guide for practitioners, *Food Security in Practice: Using Gender Research in Development,* by Agnes R. Quisumbing and Bonnie McClafferty (March 2006), embodies the efforts of IFPRI researchers to maximize the relevance and accessibility of their findings to their audiences.

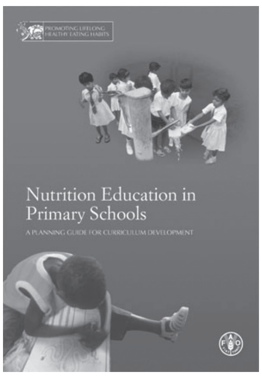
FAO/WHO Report on upper levels of intake for nutrients and related substances

A recent report from a joint Food and Agriculture Organization/World Health Organization (FAO/WHO) technical workshop lays out the scientific principles for establishing upper levels of intake for nutrients and related substances. The work was undertaken in response to the growing international interest in identifying such levels of intake. The report should assist those responsible for ensuring public health protection, given the increasing use of highly fortified foods and supplements. The report is available in hardcopy and electronically at: http://www.who.int/ipcs/methods/en/.

New FAO publications on nutrition in schools

The Food and Agriculture Organization (FAO) Nutrition and Consumer Protection Division is pleased to announce its latest publications for assisting developing countries in the improvement of both nutrition and education through school-based interventions.

Nutrition education in primary schools—A planning guide for curriculum development **(FAO, Rome, 2005; 526 pages)**



Efforts to protect and promote good nutrition need to be an integral part of every country's fight to eliminate poverty, food insecurity, hunger, and malnutrition. Effective nutrition education in schools can make an important contribution toward this goal.

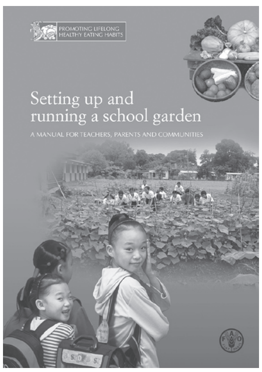
The Food and Agriculture Organization (FAO) has developed this innovative material for governments and school systems wishing to establish nutrition education programs and curricula in primary schools with the aims of making education more relevant to children's needs and of promoting lifelong healthy eating habits among current and future generations.

A basic concept that underlies the orientation of the Planning Guide is that nutrition education is much more that just what is taught in the classroom. Given that the physical, social, and educational environment of the entire school, along with the support and interaction between the school and local community, are also important for nutrition education, the Planning Guide advocates development of a tripartite curriculum that capitalizes on the learning and support opportunities found within classrooms, schools, and communities.

The Planning Guide is a resource package consisting of three main elements: *The Reader* is a book (240 pages) that explains key concepts of nutrition education and describes the process of developing tripartite curricula. *The Reader* refers to *The Activities,* a set of worksheets (270 pages) that takes participants through the planning exercise. *The Classroom Curriculum Chart* is a poster providing learning objectives for nutrition education at different ages in primary schools. Additional working materials offer helpful inputs and tools for the planning process.

The resource package is currently available in English only; a French version is under preparation and a Spanish translation will follow.

Setting up and running a school garden. A manual for teachers, parents and communities. **(FAO, Rome, 2005; 198 pages)**



FAO has prepared this manual to assist schoolteachers, parents, and communities who wish to start or improve a school garden with the aim of helping schoolchildren to grow in both mind and body.

Children's health is the concern of the whole school and community. The classroom curriculum, extracurricular activities, the school establishment, and the school environment should reinforce each other and work together with the family and community to ensure that children can realize their basic rights to education and to adequate nutrition.

The School Garden manual works on all these fronts—growing food in the garden, learning about it in the classroom, involving the school meals service, and bringing in the family and community to support the program. This multifaceted approach is the best way to successful education for better nutrition and learning. More than that, it may play a part in promoting the health not only of the children but also of their families and of the natural environment.

In preparing this manual, FAO has drawn upon experiences and best practices derived from school garden initiatives all over the world. The manual takes the user through all the steps of planning a garden project: deciding what the garden is for, planning how to get help, learning how to prepare the site, organizing the work, and motivation. The appendices contain horticultural notes and fact sheets on nutrition.

Parts 3 to 10 of the manual have outlines of appropriate lessons to be done in class. These are aimed at children aged 9 to 14 years and supplement and support garden activities. They focus not only on knowledge and skills, but also on awareness, life skills, and promotion of positive behaviors. Such "garden lessons" have enormous educational value and bridge theory and practice, reinforcing classroom learning with hands-on experience and observation, and vice versa.

Please contact the Director, Nutrition and Consumer Protection Division (AGN) for additional information or to order copies: nutrition@fao.org.

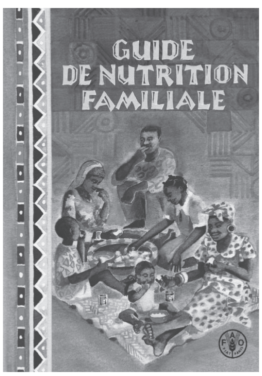
French and Spanish versions of FAO family nutrition guides

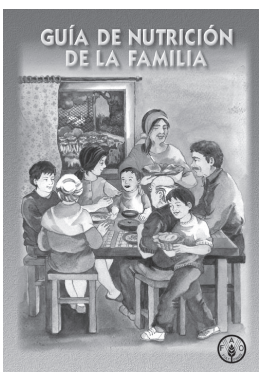
FAO is pleased to announce publication of two more language versions of its very successful *Family Nutrition Guide* that was initially published in English in 2004.

Guide de nutrition familiale (FAO, Rome 2005; 133 pages) is a French version of the original document. The Spanish version, *Guía de nutrición de la familia* has also been adapted to the needs and the situation of countries in the Latin America region.

The *Family Nutrition Guide* is an essential nutrition education resource written primarily for health workers, nutritionists, agricultural extension workers, and other development workers who want to create more effective nutrition education and communication programs, materials, and training activities in their country.

In addition to a much-needed up-to-date compendium of technical nutrition facts, the document provides guidance in the implementation of community-based nutrition education interventions, as well as suggestions on how to share this information working with groups of people.





The specific format of the document makes it an easy-to-use model for effective national and local nutrition education training and communication materials. The document also allows for the easy preparation of target group-oriented nutrition fact sheets, radio features, visual support materials for health campaigns, etc.

An Arabic version is in preparation and a Swahili version is planned.

Please contact the Director, Nutrition and Consumer Protection Division (AGN) for additional information or to order copies: nutrition@fao.org.

FAO and WAGGGS youth education project: The Right to Food: A Window on the World

In June 2006, the Food and Agriculture Organization (FAO) launched a youth education initiative called "The Right to Food: A Window on the World." Undertaken in collaboration with the World Association of Girl Guides and Girl Scouts (WAGGGS), this worldwide initiative aims to provide information and raise awareness among children and young people about the right to food, with the purpose of encouraging them to take action against hunger in the world.

A comic-book style publication, with eight different stories devoted to illustrating the right to food issues in eight selected countries (Brazil, Canada, India, Indonesia, Italy, Jordan, Sierra Leone, and Uganda), has been produced using language that presents the issues in a simple, understandable way in an attractive style that will capture the attention of young people. Unique features of the publication are the development of the artwork by young people for young people through national drawing competitions, and the development of the stories through collaboration with country nationals working in food security and the right to food.

These materials will help young people to understand that each individual has the right to adequate food and that government, consumer organizations, the private sector, communities, and families have an obligation to help protect, promote, and support that right. The book, available in six languages (Arabic, English, French, Italian, Portuguese, and Spanish) is accompanied by an activity and teaching guide for teachers and youth leaders.

Dissemination of these materials is being carried out through a number of channels, including the WAGGGS national member organizations in 144 countries, FAO country offices, National Alliances Against Hunger, and the Feeding Minds, Fighting Hunger global education initiative. The materials may be downloaded from the Feeding Minds, Fighting Hunger website (www.feedingminds.org); printed copies and a CD-ROM version are also available. For further information or to order copies, contact one of the above-mentioned offices or visit wagggs@wagggsworld.org or RTF-Youth@fao.org.

Micronutrient Forum

April 16–18, 2007. Micronutrient Forum. Consequences and Control of Micronutrient Deficiencies: Science, Policy, and Programs—Defining the Issues. Istanbul, Turkey. For information contact: Micronutrient Forum Secretariat. Tel: 202-659-9024; Fax: 202-659-3617; e-mail: mnforum@ilsi.org; website: www.a2zproject.org.

Correction to Vol. 27, No. 1

UNU Food and Nutrition Program

Each year in its March issue, the *Food and Nutrition Bulletin* prints a list of organizations associated in various ways with the United Nations University's Food and Nutrition Program, starting with the four coordinating institutions represented on its steering committee. Through an error in waiting for confirmation of a change in Division Head, Cornell University was omitted entirely from the list of coordinating institutions. We regret the omission and indicate below the correct entry for Cornell University.

Coordinating Center

Division of Nutritional Sciences
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Program Director: Patrick J. Stover
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International agencies

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The United Nations Children's Fund (UNICEF)

Bilateral agencies

United States Agency for International Development (USAID)

Nongovernmental organizations

International Life Sciences Institute (ILSI)

Corporations

Akzo Nobel Chemicals
DSM Nutritional Products
Kraft Foods
Procter & Gamble Co.
Unilever

Useful web sites and free materials

Access to Global Online Research in Agriculture (AGORA)	www.aginternetwork.org/en/about.php
Food and Agriculture Organization (FAO)	www.fao.org
International Atomic Energy Agency (IAEA)	www.iaea.org
International Life Sciences Institute (ILSI)	www.ilsi.org
International Nutritional Anemia Consultative Group (INACG)	http://inacg.ilsi.org
International Nutrition Foundation (INF)	www.inffoundation.org
International Vitamin A Consultative Group (IVACG)	http://ivacg.ilsi.org
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Iron Deficiency Project Advisory Service (IDPAS)	www.micronutrient.org/idpas
The Micronutrient Initiative	www.micronutrient.org
Pan American Health Organization (PAHO)	www.paho.org
Save the Children	www.savethechildren.org
Unilever	www.unilever.com
United Nations Children's Fund (UNICEF)	www.unicef.org
United Nations University (UNU)	www.unu.org
UN Standing Committee on Nutrition (SCN)	www.unsystem.org/scn
World Bank	www.worldbank.org
World Food Program	www.wfp.org
World Health Organization (WHO)	www.who.int/en

Note for contributors to the *Food and Nutrition Bulletin*

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

Ethical approval of studies and informed consent. For investigations of human subjects, authors should state in the Methods section the manner in which informed consent was obtained from the study participants (i.e., oral or written), and describe how the study investigators protected the rights of participants as described in the Declaration of Helsinki.

Language. Contributions must be submitted in English.

Format. **Manuscripts should be prepared on a computer, and submitted electronically via e-mail directly to the Managing Editor.**

Abstract. An abstract of not more than 250 words should be included at the beginning of the manuscript, in the following format:

» *Background.* The context of the problem you are investigating, with relevant historical information.
» *Objective.* A one- or two-sentence description of the purpose of the study and what you expected to find.
» *Methods.* Outline of study design, subject selection, analytical methods, data analysis.
» *Results.* What you found based on your data. Give specific data and their statistical significance here if possible.
» *Conclusions.* One- or two-sentence description of what you conclude from your results.

Emphasize new and important aspects of the study or observations. Do not include any information that is not given in the body of the article. Do not cite references or use abbreviations or acronyms in the abstract.

Key words. Authors should provide a minimum of four key words for the article.

Tables and figures. Tables and figures should be placed on separate pages in the manuscript file. Footnotes should be keyed to the relevant data points by letters or symbols. Figures should be submitted electronically, as part of the manuscript file or as a separate electronic file. The original data files for figures that use bar graphs, scatterplots, or other graphic representations of data should be sent along with the manuscript. Please double-check your data for accuracy and consistency with the text.

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

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—standard journal article (list all authors):

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

—corporate author:

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

Book or other monograph reference

—personal author(s):

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

—corporate author:

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

—editor, compiler, chairman as author:

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

—chapter in book:

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

World Wide Web reference

7. WHO HIV infections page. WHO web site. Available at: http://www.who.int/topics/hiv_infections/en/. Accessed 12 October 2004.
8. Nielsen J, Palle V-B, Martins C, Cabral F, Aaby P. Malnourished children and supplementary feeding during the war emergency in Guinea-Bissau in 1998–1999 [serial online]. Am J Clin Nutr; 2004; 80:1036-42. Available at: http://www.ajcn.org/cgi/content/full/80/4/1036. Accessed 12 October 2004.

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