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Effect of supplementary feeding on recovery from mild to moderate wasting in preschool children[1–3]

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ABSTRACT Three-month recovery rates from moderate wasting (< 90% weight-for-length) were compared in 6–24-mo-old children in four Guatemalan villages that had been randomly assigned to receive a moderate (Atole) or low (Fresco) energy supplement. The recovery rate (Rr) in the Atole villages was 12% higher than in the Fresco villages ($P < 0.05$). This effect was above all due to the children in the Atole villages who consumed ≥ 10% of the daily recommended dietary intake of energy (RDI) from the supplement (high-Atole group) and whose total energy intake (including home diet) was 10.5% of the RDI higher than a comparable high-Fresco group with low supplemental energy intake. All those in the high-Atole group whose wasting was due to malnutrition recovered. Much of this recovery (range 29–52%) was due to the increased supplementation. This proportion rose after potential confounding variables were controlled for. *Am J Clin Nutr* 1991;54:62–8.

KEY WORDS Protein-calorie malnutrition, recovery, supplementation field trial

Introduction

Moderately to severely wasted children are often referred to supplementary feeding programs. The proportion of children who are wasted as evidenced by low weight given their height is large (1). For example, in 1980 25% of children between ages 6 mo and 5 y in a national sample of Guatemala were classified as moderately to severely wasted because they weighed < 90% of the National Center for Health Statistics (NCHS)–World Health Organization (WHO) references for weight-for-height (INCAP, unpublished observations, 1980).

Reported recovery rates (Rrs) from mild to moderate protein-energy malnutrition (PEM) in children attending nutrition-rehabilitation centers range from 40% to 80% (2, 3). However, none of the studies in these centers had adequate control groups. Therefore, Rrs reported cannot be attributed solely to supplementary feeding.

In a review of supplementary feeding trials, Habicht and Butz (4) concluded that supplementary feeding, when given in adequate amounts to malnourished children, has a positive effect on growth. In contrast, Beaton and Ghassemi (5) in their metaanalysis of supplementary feeding programs concluded that the effect of supplementation on "anthropometric improvement was surprisingly small." Much of their metaanalysis then went on to seek reasons for this small effect.

Given the importance of supplementary feeding programs as strategies for the control of undernutrition, the objective of this study was to quantify the effect of supplementary feeding on the recovery from mild to moderate wasting in a supplementation trial in Guatemala, using indicators of wasting and recovery that are commonly employed in nutrition and public health programs.

Subjects and methods

Study population and research design

The data used for this analysis were collected during a controlled supplementation trial conducted in rural Guatemala between 1969 and 1977. Detailed descriptions of the sample, methods, and quality control were published elsewhere (6). A brief description follows: Four rural Guatemalan villages that were similar in population, ethnicity, development, and geographical area were selected for the study. Two of the villages were randomly allocated to receive a high-energy (3.77 MJ/L), high-protein (63 g/L) drink called Atole. The remaining two villages were assigned to receive a low-energy (1.38 MJ/L) nonprotein supplement called Fresco. Both supplements had similar amounts of vitamins and minerals (**Table 1**). A preventive and curative health program was offered in all four villages (7). The supplements were distributed centrally in supplementary feeding centers and were available daily, on a voluntary basis, to all members of the community at two 3-h sessions. Individual intakes of children aged 0–7 y were measured and recorded at each session to the nearest 10 mL. The energy content of Atole is almost three times the energy content of Fresco. Furthermore, children in the Atole villages consumed larger volumes of supplement than did children in the Fresco villages. As a result, the

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TABLE 1
Ingredients and nutrient content of Atole and Fresco*

	Atole	Fresco†
Ingredients (g/0.18 L)		
Incaparina‡	13.5	—
Dry skim milk	21.6	—
Sugar	9.0	13.3
Flavoring agent	—	2.1
Nutrients (per 0.18 L)		
Energy (kJ)	682	247
Protein (g)	11.5	—
Fats (g)	0.7	—
Carbohydrates (g)	27.8	15.3
Ascorbic acid (mg)	4.0	4.0
Calcium (g)	0.4	—
Phosphorus (g)	1.1	1.1
Thiamine (mg)	0.3	—
Riboflavin (mg)	1.5	1.5
Niacin (mg)	18.5	18.5
Vitamin A (mg)	1.2	1.2
Iron (mg)	5.4	5.0
Fluoride (mg)	0.2	0.2

* Contents per cup; cup volume = 0.18 L.

† Both preparations were distributed daily from January 1, 1969, to February 28, 1977. Vitamins and minerals were added to the Fresco on October 1, 1971.

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average energy intake from the supplement is higher in the Atole than in the Fresco villages. For example, the mean daily supplement intake in moderately wasted children was ~11% of the daily recommended dietary intake of energy (RDI) (8) for the Atole group and only ~1% for the Fresco group in children aged 6–24 mo (J Rivera, unpublished observations, 1988). Therefore, the Fresco group can be considered a nonsupplemented group.

The sample included children aged 6–24 mo. The analyses were based on six child-age intervals: 6–9, 9–12, 12–15, 15–18, 18–21, and 21–24 mo. Because the study was longitudinal, some children participated in more than one child-age interval. The study was conducted according to ethical guidelines of the National Institutes of Health.

The data relevant to this paper were collected as follows: weight and length were obtained every 3 mo for the first 2 y of age. Home dietary intake (excluding breast-feeding) obtained by a 24-h dietary-recall method was collected every 3 mo for children aged 18–24 mo. Morbidity data were collected every 2 wk during home visits. Mothers were asked about the presence and duration, during the last 2 wk, of signs of respiratory infection and signs of other infections, including diarrhea and fever. Socioeconomic and demographic data about the child's family, as well as characteristics of the house and of the parents, were also collected, of which the following were used: years of school, height of both parents, mother's parity, number of persons living in the house, number of persons per room, and duration of breast-feeding. Three scores were generated from the information about the house characteristics and from interviews and tests of the mothers: a maternal vocabulary score, a maternal modernity score, and a house-quality score (J Rivera, unpublished observations, 1988).

Analytic approach

Definition of wasting, recovery, recovery rates, and attributable benefit. Children were classified as wasted at the beginning of the 3-mo intervals if they weighed < 90% of the expected weight, given their length, according to the NCHS-WHO reference standard (9). A wasted child was considered to have experienced recovery if its weight-for-length at the end of the interval was > 90% of the NCHS-WHO references of weight-for-length. Rr was defined as the proportion of children who were initially wasted and whose weight-for-length was ≥ 90% at the end of 3 mo. The attributable benefit (AB), or the effect attributable to the supplementation, was obtained by subtracting from the Rr of the supplemented group the Rr of a nonsupplemented, otherwise comparable group. This is analogous to the attributable risk to a disease caused by a pernicious exposure (10).

Measures of effects. Observations in the estimation of the Rrs from child-age intervals were not independent because a number of siblings were included in the group of wasted children. Moreover, some children experienced repeated episodes of wasting, thus contributing more than one observation in the sample. Therefore, to take into consideration these cluster effects, households were used as the unit of analysis. The within household Rrs were obtained and the means of these rates (mean household Rrs) and their variances were used for the calculations that follow.

To determine actual supplementation, the percentages of RDI (8) from the supplement as well as the diet of wasted children were obtained. These were averaged within households (mean household % RDI). The means of these averages were compared between groups of children in the Atole and Fresco villages to show that true supplementary feeding had occurred.

Overall village-level effects. Rrs were compared between Atole and Fresco villages. The mean household Rrs of wasted children from the two Fresco villages were subtracted from the mean household Rrs of wasted children from the two Atole villages to compute the overall AB. This difference was tested for one-tailed statistical significance by an analysis of variance by using the village as the unit of analysis and by using an arc sine transformation to stabilize the variances (11). This analysis takes advantage of the original design of the study in which two villages were randomly assigned to the Atole treatment, and of the a priori expectation that the children receiving Atole will benefit more than the children receiving Fresco.

The second approach was to study household effects by taking advantage of the information about individual supplement intake. For example ~45% of the 6–24-mo-old children ingested ≥ 10% of the RDI from the supplement in the Atole villages. These children are referred to as being in the high-Atole groups.

The groups used for comparison with the high-Atole groups were those children above the 55th percentile of the distribution of supplement intake in the Fresco villages. These are referred to as high-Fresco groups.

The mean household Rrs of wasted children in the high-Fresco group were subtracted from the mean household Rrs of wasted children in the high-Atole group to obtain the AB. The AB variance is the sum of the two variances of the Rrs being subtracted. In addition, the mean household Rr of the high-Atole and of the high-Fresco groups was compared. The difference between the means was converted to standard normal deviates Z and was tested for statistical significance (11).

To show how similar the ABs would have been if other comparison groups were used, we also present the Rrs of 6–24-mo-old children in the low-Atole (< 10% of RDI who were at or below the 55th percentile of supplement intake from Atole) and the low-Fresco (at or below the 55th percentile of supplement intake from Fresco) groups. The differences between the Rrs of the high-Atole group with the Rrs of the low-Atole, low-Fresco, and high-Fresco groups were obtained and their statistical significances were computed as described for the ABs.

Control for potential confounding variables. The use of the high-Fresco group for comparison with the high-Atole group maximizes the likelihood of having similar groups, in terms of characteristics that led to self-selection. However, the procedure employed for the selection of comparison groups does not guarantee equal distribution of all the potential confounding variables among the comparison groups. The variables that were identified as potential confounding variables were those variables with values that were significantly different between the high-Atole and high-Fresco groups and which are known to be or are suspected to be independent causes of recovery from wasting.

Logistic-regression models were employed to assess the effect of supplementation on recovery from wasting after controlling for the measured potential confounding variables (12). The dependent variable was a dichotomous variable indicating a child's recovery within an interval from wasting as defined above. The independent variables were an indicator variable for treatment groups (high Atole and high Fresco), the potential confounding variables, and other variables that were independent causes of recovery.

Rrs for the well-supplemented (high-Atole) and poorly supplemented (high-Fresco) groups were estimated by using the logistic-regression coefficients. For this estimation the independent variables were held constant at their mean values. The estimated Rrs from the model were employed to obtain adjusted AB values after the potential confounding variables were controlled for.

The child-intervals used as units of analysis for the logistic-regression models have the cluster effects described above, which may result in an underestimate of the standard errors of the logistic-regression coefficient. Therefore, a correction factor for the clustering effect was used to multiply the standard errors of the regression coefficient. The correction factor (CF) is based on the difference between the observed Rr for the household and the household's mean predicted Rr values from the logistic model as follows:

$$\mathrm{CF} = \frac{\sum_1^{\mathrm{H}} \left(\dfrac{n(\mathrm{MRr} - \bar{x})^2}{\bar{x} * (1 - \bar{x})} \right)}{\mathrm{H} - \mathrm{K}} = \frac{\sum_1^{\mathrm{H}} \left(\dfrac{\mathrm{A}}{\mathrm{B}} \right)}{\mathrm{H} - \mathrm{K}}$$

where $\sum_1^{\mathrm{H}}$ indicates summation over households, n is the number of observations per household, H is the total number of households, K is the number of parameters in the logistic-regression model, MRr is the mean Rr for each household, and $\bar{x}$ is the mean of the predicted probability of recovery for all observations within a household from the logistic-regression model. The numerator (A) is the squared difference between the observed and the predicted (from the logistic model) rate of recovery of the household (the cluster). The denominator (B) is the binomial variance for the household, which is the expected variance if there is no household clustering. The correction factor is therefore the actual variance, which includes a cluster effect, divided by the binomial variance. In the absence of a cluster effect, both variances are identical, and the ratio will be 1. The 95% confidence interval was obtained by an approximation (13). The logistic-regression coefficients and the corresponding corrected standard error were used to obtain confidence limits for the odds ratios that were then transformed to the antilog form.

Effect of regression toward the mean on the recovery rates in the high-atole group. In the high-Atole group Rr includes the AB. The part of the Rr that is not attributable to supplementation corresponds to the Rr of the high-Fresco group. This component of the Rr includes the effect of regression towards the mean (14), because weight-for-length that is under- or overestimated at one point in time will tend to be higher or lower, respectively, on the next measurement. This is because of imprecision and other components of unreliability reported for these children elsewhere (15).

The fraction of Rr that results from regression towards the mean can be estimated. The percentage of children in the high-Atole and the high-Fresco groups who were misclassified as falling below the 90% weight-for-length of the standards (9), at the beginning of the period, as a result of unreliability in the measurement, is a slight overestimation of this fraction. This percentage was obtained as follows: *1*) the standard normal deviate (Z) corresponding to 90% in the distribution of percent weight-for-length values was obtained for each age interval in the high-Atole and high-Fresco groups, *2*) the product of the standard normal deviate (Z) and the square root of the measurement reliability of weight-for-length (sqR) was also obtained (ZsqR), *3*) finally, the proportion of recovery due to regression towards the mean was estimated by subtracting the area under the curve from 0 to ZsqR from the area under the curve from 0 to Z, both multiplied by 100. These areas were obtained from the cumulative normal frequency distribution (11) because the distribution of the weight-for-length values were normally distributed in this population.

Reliability was estimated from the proportion of the variance not due to week-to-week variability of the measured values (16). This reliability is not directly available for the weight-for-height measurement in this data set but the 2-wk reliabilities for the weight and length measurements are available for this study in a publication (15) that used data from Martorell et al (17). These data meet the requisites for Fieller's formula (18) to calculate the weight-for-length reliability from the weight and height reliabilities as follows:

$$[\mathrm{S}_y^2 \mathrm{R}_y - 2\mathrm{b}r\mathrm{S}_x\mathrm{S}_y(\mathrm{R}_x\mathrm{R}_y) + \mathrm{b}^2\mathrm{S}_x^2\mathrm{R}_x]/\bar{x}^2\mathrm{S}_\mathrm{b}^2$$

where y is the observed weight, R is the reliability calculated from data in reference (17), S^2 is the variance, b is the mean percent weight-for-length, r is the correlation coefficient between observed weights and weights from standard given observed lengths, and $\bar{x}$ is the mean weight from standard given observed length (9).

Results

Household Rrs at the end of 3-mo supplement intervals in the Atole villages were 0.49 and 0.52 ($\bar{x}$ = 0.50) and in the Fresco villages were 0.42 and 0.35 ($\bar{x}$ = 0.38). The overall village level effect of supplementary feeding was 0.12 ($P < 0.05$), which

TABLE 2
Household recommended dietary energy intake from the supplements from 6–24 mo in moderately wasted children, by level of participation*

Participation	Atole	Fresco
High	17.3% ± 5.1 [72]	2.5% ± 1.5 [97]
Low	5.2 ± 3.1 [85]	0.4 ± 0.3 [118]

* High participation, above the 55th percentile of supplement intake in 3-mo intervals; low participation, at or below the 55th percentile. $\bar{x}$ ± SD; number of households in brackets. Average recommended intakes for ages 6–24 mo (8).

corresponds to the difference between the Fresco and the Atole mean village Rrs.

The dose-response analysis for energy intake from home diet and supplement for high- and low-supplement groups is presented in **Table 2,** which shows the percent of RDI provided by the supplement in children aged 6–24 mo by type of supplement and level of participation. The analysis of the home-dietary-intake information in children between 18 and 24 mo of age (results not shown) revealed that on average, home diet, which excluded breast milk, provided 59.7 ± 4.7% of the RDI across the four groups in Table 2. There were no statistically significant differences between the four groups. Hence, there is no evidence of a replacement effect of the supplement.

Table 3 presents household Rrs by treatment and level of participation. The Rr from moderate wasting in the high-Atole group was 0.59 at the end of 3 mo of supplementary feeding (Table 3) compared with 0.41, 0.44, and 0.36 for the high-Fresco, low-Atole, and low-Fresco groups, respectively. The differences between the Rrs of the high-Atole groups and the high Fresco, low-Atole, and low-Fresco groups were 0.18, 0.15, and 0.23, respectively, which were all statistically significant ($P < 0.025$, one-tailed test). In contrast, the differences among the high-Fresco, low-Atole, and low-Fresco groups were small (0.03 to 0.08). In other words, the use of any of the other three groups for comparison with the high-Atole group demonstrated a similar effect of high levels of supplementation on recovery from wasting. The high-Fresco group was chosen for comparison with the high-Atole group because it is similar to the high-Atole group in level of participation, and as a result, it is probably also more comparable with the high-Atole group in nonmeasured potential confounding variables. Yet, the high-Fresco group nevertheless received low amounts of energy from the supplement.

Finally, the 0.15 difference in Rrs between the high- and low-Atole groups was significantly different ($P < 0.05$) from the difference between high- and low-Fresco groups, which was only 0.05 and not statistically different from zero.

Table 4 presents the mean values for the high-Atole and high-Fresco groups of a list of potential confounding factors. Only three variables were statistically significant and likely to affect the AB results. In two of them the values of the high-Atole group were suspected to be associated with low Rrs (negative confounding variables): lower duration of breast-feeding and more days with respiratory disease. Only birth weight was considered to be a potentially positive confounding variable. The high-Atole group had higher birth-weight values than the high-Fresco group. Although not very likely, birth weight could be associated with high Rrs.

Table 5 presents results from logistic-regression models in which the three potential confounding variables were included as independent variables. Seven other variables that are known or are suspected to be independent causes of recovery were also included as independent variables even though they did not differ between treatments. The seven variables included, along with the potential confounding variables, were as follows: age, gender, initial weight, initial percent weight-for-length, days with fever and days with diarrhea during the study period, and mean dietary energy intake from 18 to 24 mo of age.

AB values derived by using direct estimation were compared with the estimations from probabilities obtained from the logistic models after potential confounding variables were controlled for. Odds ratios for type of supplementation (Atole or Fresco) among the high-level participants are also presented. The resulting odds ratio for recovery after potential confounding variables were controlled for was 2.36 (95% two-tailed confidence interval 1.05, 5.29) 3 mo after initiation of supplementary feeding.

Results from logistic models with only the three potential confounding variables were similar to the AB results presented above (results not shown).

Overall, < 1.6% of the Rr could be attributed to the regression towards the mean resulting from measurement imprecision or to other sources of the unreliability.

Discussion

Past studies showed Rrs of mild to moderately wasted children that ranged from 40% to 80%; however, these studies did not use comparison groups. In the following discussion we first

TABLE 3
Recovery rate (Rr) and differences in Rr, by level of participation, in the supplementation programs for moderately wasted children (<90% weight-for-length) 3 mo after beginning supplementation at ages 6–24 mo

Level of participation	Atole			Fresco		
	Number of households	Rr	Var*	Number of households	Rr	Var
High	72	0.59[a]	0.1655	97	0.41[b]	0.1938
Low	85	0.44[b]	0.1781	118	0.36[b]	0.1687
Differences		0.15[c]			0.05[d]	

* Variance of household Rrs. a Significantly different from b (one-tailed $p < 0.025$); c Significantly different from d (one-tailed $p < 0.05$).

TABLE 4
Descriptive statistics of potential confounding for moderately wasted children (<90% weight-for-height) 6–24 mo old in the high-Atole and high-Fresco groups*

Variables	High Atole	High Fresco
Parent's education		
Years of school (mother)	1.28 ± 1.70 [68]	1.03 ± 1.49 [96]
Years of school (father)	1.13 ± 1.53 [38]	1.36 ± 1.88 [45]
Maternal vocabulary score	5.93 ± 2.82 [43]	6.06 ± 3.30 [49]
Parent's height		
Mother's (cm)	149.7 ± 5.40 [72]	149.3 ± 5.57 [97]
Father's (cm)	162.0 ± 6.08 [57]	161.7 ± 5.06 [73]
Mother's modernity score	5.94 ± 2.08 [43]	5.31 ± 2.82 [49]
Demographic variables		
Mother's parity	4.24 ± 3.23 [45]	3.21 ± 2.74 [43]
Number of persons in household	7.10 ± 2.36 [72]	6.89 ± 2.41 [96]
Sanitary conditions		
House quality	5.54 ± 2.06 [22]	5.04 ± 4.11 [25]
Persons per room	4.54 ± 2.20 [72]	4.19 ± 2.37 [96]
Children's health		
Time with diarrhea (%)	0.15 ± 0.16 [66]	0.13 ± 0.17 [89]
Time with respiratory infection (%)	0.49 ± 0.27 [66]	0.35 ± 0.29 [89]†
Time with fever (%)	0.03 ± 0.05 [66]	0.03 ± 0.05 [89]
Home dietary intake at 18–24 mo (% RDI energy)	61.4 ± 20.8 [66]	63.5 ± 23.3 [82]
Duration of breast-feeding (mo)	16.6 ± 5.24 [70]	19.4 ± 5.32 [88]†
Birth weight (kg)	3.09 ± 0.45 [59]	2.90 ± 0.42 [69]†

* $\bar{x} \pm$ SD; number of households in brackets.
† Significantly different from high-Atole group, $P < 0.10$.

compare village level Rrs of wasted children between two populations: one population with access to a supplement that provided nutritionally significant amounts of energy and a second population with access to a low-energy, no-protein supplement. Our second comparison is between children with similar levels of participation with respect to supplementation with different energy and protein densities. We then show that the effects of supplementary feeding remain after controlling for third factors. We finally discuss the implications of our results for the design and impact evaluation of nutrition interventions.

The overall village level effect of supplementation with Atole was 12%. The village level approach takes advantage of the original randomized design of the study. Surprisingly, even with only two replicates per treatment the one-tailed, P value associated with the supplement effect was < 0.05.

This effect was achieved despite the fact that 50% of the children in the Atole villages consumed < 10% of their RDI from the supplement.

We assessed the effect of larger amounts of supplement intakes by comparing Rrs of children in the high-Atole group, whose supplement intake was ≥ 10% of their daily RDI, with the Rrs of the high-Fresco group. The groups were comparable except that the energy intake from the supplement was much less in the Fresco group. Only a negligible part of the Rr < 1.6%, was due to imprecision of measurement or to week-to-week unreliability in weight-for-height. Thus the Rrs of 0.36–0.41 in the high-Fresco and the two other low-supplementation groups represent real recovery from wasting, which is not due to supplementation.

Fifty-nine percent of 6–24-mo-old wasted children in the high-Atole group recovered within 3 mo as compared with 41% in the high-Fresco group, representing a 44% improvement in Rrs for the supplemented children. Therefore, the AB was 18% (95% confidence interval 5–30). These Rrs and AB values are underestimates of the true values for the following reasons.

Twenty percent of the children in the high-Atole group were below the 90% cutoff point for weight-for-length, as compared with 25% in the high-Fresco group. The 90% weight-for-length cutoff point corresponds roughly to −1.25 SD of the NCHS-WHO weight-for-length distribution (8). Thus, in a healthy population one would expect ~10.5% of the children to be below the 90% cutoff point. This means that only 48% and 58% of the high-Atole and high-Fresco groups, respectively, who were below the 90% cutoff for weight-for-length were truly wasted. Thus, the Rr should be corrected to 123% and 71%, respectively, for high-Atole and for high-Fresco groups (the percent of the possible recovery). The AB is ≥ 29% (100–71%) and perhaps as high as 52% (123–71%) when these corrected figures are used. The AB of 18% is clearly an underestimation of the effect attributable to supplementary feeding.

There is evidence of true supplementation. The high-Atole group consumed larger amounts of supplement (17.3% of RDI) than did the high-Fresco group (2.5% of RDI) whereas the home dietary intake did not differ between the two groups. The energy intake from the supplement was about one-fourth the energy intake in the home diet for the high-Atole group whereas in the high-Fresco group the energy intake from the supplement was < one-twentieth of the energy intake in the home diet. No information is available about the intake of breast-milk. However, a larger proportion of children were breast-fed between 18 and 24 mo of age in the high-Fresco group (50%) than in the high-Atole group (35%). Assuming an average intake of 570 g breast milk in both groups and an energy content of 0.60 kcal/g breast milk (20), the higher breast-milk intake in the high-Fresco group would be equivalent to 51 kcal/d or ~4.3% of the RDI for energy. Therefore, even after taking into account the possible extra energy intake from breast milk in the high-Fresco group, there would still be a net increase of energy intake in the high-Atole group of ~10.5% (17.3% − 2.5% − 4.3%) of the RDI for energy.

There is also evidence of low dietary intakes (70–75% RDI) even after taking into account the possible intake of breast milk. The average weight increment from 18 to 24 mo of age in chil-

TABLE 5
Attributable benefit values (direct estimation and predicted from logistic models) and odds ratios for recovery from wasting (<90% weight-for-length), ages 6–24 mo

Interval duration (mo)	3
Number of child-intervals*	
Atole	99
Fresco	117
Attributable benefit	
Direct estimation	0.1764†
Predicted from models‡	0.2037
Odds ratio	2.36†

* For direct estimation.
† $P < 0.05$ (one-tailed t test).
‡ Potential confounding variables controlled for.

dren in the high-Atole group who recovered within 3 mo was 1.1 kg. The rate of weight gain per body weight per day was 1.5 $g \cdot kg^{-1} \cdot d^{-1}$ much lower than the rate expected in severely wasted children with similar energy intake during nutrition rehabilitation, from 5 to 10 $g \cdot kg^{-1} \cdot d^{-1}$ (21). The difference in the rate of weight gain may be due to one or more of the following reasons: *1*) the energy and protein utilization for tissue deposition probably varies with initial nutritional status. The average weight deficit in our group was 1.23 kg as compared with 3 kg in the study of Ashworth and Millward (21). *2*) The high prevalence of infection in our group might have increased energy and nutrient needs. The prevalence of diarrhea in these villages was high. For example, on average, children between 6 and 18 mo of age (the time when diarrhea is most prevalent) had diarrhea > 10% of the time (19). *3*) A less likely possibility is that the energy and protein utilization for tissue deposition may vary as a result of the type of diet.

The use of a cutoff point for the definition of wasting and recovery rather than the use of absolute weight-for-length increments may lead to errors in the assessment of nutritional improvement, particularly if the initial percent of weight-for-length values was different among groups. For example, a child with an initial percent weight-for-length of 89 may be classified as recovered even if the weight-for-length increment is as low as 1%. In contrast, a child with an initial percent weight-for-length of 79 and an increment as high as 10% will be classified as nonrecovered. This was not the case in the study groups. Results not presented show that the percent weight-for-length values at the beginning of the study period were similar in the four groups studied but that the percent weight-for-length increments were larger in the high-Atole group than in the other three groups. In other words, results of analyses that used increments of percent weight-for-length are consistent with the results presented, which used the cutoff point as the definition of recovery.

The units of randomization of treatments were the villages and not the households. Therefore, for comparing the effect of supplement according to level of supplement ingestion, potential confounding variables must be controlled for. In the logistic-regression models, measured potential confounding variables were taken into account. Although only one variable (birth weight) was identified as a potential positive confounding variable, because it could have explained the positive association between supplementary feeding and recovery, we also controlled for two potential negative confounding variables (breast-feeding and respiratory disease) that were associated with the type of supplement among the high-Atole and high-Fresco groups and for seven other variables. The predicted AB estimated from the logistic-regression results was larger than the direct estimate of the AB, indicating that the unadjusted AB was not artifactually high.

Five potentially confounding variables (father's years of school, parity, vocabulary and modernity scores of the mother, and house quality) had many cases with missing values. The probability of selecting these variables as potentially confounding may have been reduced because of lack of power. However, the effect of such variables on recovery should have been mediated through increased illness or reduced dietary intake, both of which were judged not to be potential positive confounding variables and had adequate sample sizes.

The above analyses do not fully address the criticism that is often made of studies in which supplements are consumed voluntarily. If nonmeasured characteristics of children who were self-selected for participation in the supplementary feeding program are associated with recovery, then self-selection can lead to confounding. However, the selection of the high-Fresco group for comparison, a group that was also self-selected for participation, reduces the chance of having confounded results. For example, if recovery was the result of maternal concern and not of supplementation, and the children of more concerned mothers in both the Atole and Fresco villages participated in the supplementary feeding program, one would expect to have a similar effect of nutritional concern on Rrs in the high-Atole and the high-Fresco group, which would be true for all measured and unmeasured factors associated with participation.

One can postulate that self-selection for participation in the supplementary feeding program was not the same in the Fresco and Atole villages. For example, the more concerned women in the Fresco villages may not have participated in the program because they knew that the supplement was not a high-energy, high-protein supplement, whereas the concerned mothers in the Atole villages may have participated. Such knowledge was unlikely, given the way the study was implemented. But if such confounding had been present, then the low-Fresco group should have had higher Rrs than the low-Atole group because the low-Fresco group would have had more concerned mothers. This was not the case. Table 3 shows that the Rrs of the low-Fresco, low-Atole, and high-Fresco groups were similar and that the Rr in the high-Atole group was the greatest and was significantly different than that for the other three groups. This dose effect (AB of 0.15) between high and low participation in the supplementation in the Atole group along with a lack of dose effect in the Fresco group reinforces the inference of an unconfounded effect of supplementary feeding on recovery from moderate wasting.

Finally, the results of the village level analysis, for which there is a probability statement of causality, makes it very unlikely ($P < 0.05$) that the ABs described are due to confounding between the comparison groups.

This article presents a methodology that can be useful for the evaluation of impact of nutrition interventions. The AB is easy to interpret by the nonscientific community. The use of comparison groups permits assessment of effects attributable to the intervention under study.

The results of the study indicate that supplementary feeding programs that increase dietary intake in children with inadequate dietary intakes by about one-tenth of their RDIs have a substantial effect on recovery from moderate wasting, even in populations with a high prevalence of diarrhea.

The Rr of 59% in the high-Atole group was similar to the Rrs found in several studies conducted in nutrition-rehabilitation centers for treatment of short duration (≤ 4 mo). From this study one can conclude that the published Rrs in nutrition-rehabilitation centers were probably about twofold greater than the AB (Rr due to the supplementation), given that the positive predictive values for children selected for supplementation in these centers were probably similar to those in our population. Nevertheless, it is likely that all the malnourished children in the nutrition-rehabilitation centers recovered because the children who did not gain weight were, as in this study, probably not malnourished. There is no need to appeal to any of the other reasons enumerated by Beaton and Ghassemi (5), such as energy spent in increased activity, to explain this nonresponse.

Therefore, in contrast to conclusions drawn from the metaanalysis by Beaton and Ghassemi (5), which could not adequately consider the positive predictive value of the selection criteria for supplementation because that information was lacking, we conclude that not only our study, but also the data in previous studies, show strong beneficial effects of food supplementation on malnourished children.

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