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Effect of a Low-Cost Food on the Recovery and Death Rate of Malnourished Children

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ABSTRACT
Objectives: Nutritional rehabilitation in Africa relies mainly on imported skim milk enriched with a sugar and salt mixture. We evaluated whether milk plus porridge made from local ingredients improves the outcome of childhood nutritional rehabilitation versus milk alone.
Patients and Methods: This study was conducted in a nutritional unit in Lacor (Northern Uganda). The porridge, made from cheap locally available ingredients (maize flour, dried fish or meat, peanut butter and oil) supplemented with proteins and fats, provides 1.1 energy units, 4.4 kJ/g. We randomly sampled the files of 100 cases discharged in October, November and December 2001 (preintervention), in 2002 (soon after intervention onset) and in 2003 (more than 1 year after intervention onset). We recorded the average hospital days and average oedema-free weight gain at discharge in the 3 groups.
Results: Average oedema-free weight gain increased from 21 g/d (95% confidence interval [CI], 12–29) in 2001 to 35 g/d (95% CI, 25–45) in 2002 and reached 59 g/d (95% CI, 51–65) in 2003. Mortality decreased from 22% to 7.8%, and nutritional failures (insufficient weight gain) decreased by greater than 50%.
Conclusions: The low-cost porridge supplement (€2640/yr per 100 children) was effective in treating malnutrition. Widespread use of the porridge, which resulted in better outcomes than milk alone, could produce a savings in the medium- to long-term, thereby releasing resources for other uses. A high-energy porridge that is made from locally available ingredients and does not require imported foods seems to be appropriate for supplementary feeding after mother's milk in this setting. ***JPGN 43:512–517, 2006.*** **Key Words:** Malnutrition—Supplemental feeding—Nutritional rehabilitation—Nutritional porridge. © 2006 Lippincott Williams & Wilkins

INTRODUCTION

The World Health Organization (WHO) guidelines for the management of severe malnutrition are widely applied in Africa, albeit with various degrees of effectiveness (1,2). The WHO 2-phase feeding strategy is effective in treating severe malnutrition in children in tropical climates (3). This consists of milk F75 (which has a moderate protein and energy content) in the early phase of severe malnutrition, and milk F100 (which has a higher energy and protein content) for maintenance. In addition to milk, supplementary feeding has been encouraged to counteract malnutrition (4,5). However, the efficacy of cereal- and legume-based supplementary feeding in large-scale programs has yet to be demonstrated (6–8). Ready-to-use food in the form of a fortified spread was effective in treating malnourished children (2,9). However, this imported, industrially prepared spread is expensive and is extraneous to local customs, which is a key factor in infant malnutrition (10). A locally produced spread is as effective at one third of the cost (11), but again it is not easily accepted in most local cultures.

At St Mary's Hospital Lacor, in the Acholi region of northern Uganda, childhood malnutrition is 1 of the leading causes of fatality, but it also underlies a significant proportion of the fatalities caused by common infections (12). About 100 severely malnourished children, admitted to the hospital according to WHO criteria (5), are seen daily at the nutritional unit of St Mary's Hospital. The unit has a good standard of medical and nursing care for children: drugs and infusions are available, except, until recently, for the treatment of AIDS. A United Nations International Children's Emergency Fund–funded nutritional rehabilitation intervention with F75 milk (skim milk with added sugar, oil and electrolytes) as starter and F100 as follow-up was set up in the unit in 1996. However, the frequent occurrence of diarrhoea and growth failure after milk ingestion suggested that some malnourished children could not fully absorb the energy provided by

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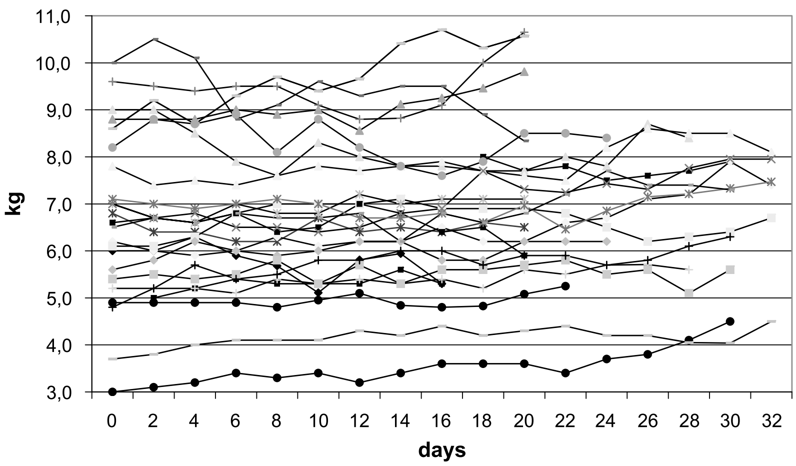

FIG. 1. Twenty individual weight curves (weight in kilograms) before nutricam administration (July 2002).

the milk. Moreover, the fatality rate in severely malnourished children undergoing nutritional rehabilitation at the unit was above 20%. This is not unusual in developing countries, but it is about 3 to 4 times higher than the fatality rate associated with nutritional rehabilitation in similar units in Africa (5). The analysis of 20 weight-growth curves of children without oedema (Fig. 1) admitted to the Lacor hospital in June and July 2002 did not show, in most cases, the expected catch-up growth after nutritional rehabilitation with milk. Finally, a significant proportion (>10%) of mothers dropped out of the programme, often because of discouraging results.

Given the disappointing results of nutritional rehabilitation with milk only, and because milk is not always available out of the hospital, thereby resulting in many relapses, we evaluated the effect of supplementary feeding with a nutritious porridge made from locally available ingredients.

PATIENTS AND METHODS

Cases and Outcome Variables

The criteria for admission to the St Mary's Nutritional Unit are age between 6 months and 6 years, severe malnutrition defined as weight less than 70% of that expected for length or height (marasmic cases), peripheral oedema score between 1 and 4+ (kwashiorkor cases) or both marasmus and oedema. Children are discharged as cured when the threshold of 85% weight-for-length and no oedema are attained.

We used a cohort study design in which different cohorts of children were studied before and after the intervention, namely introduction of porridge in the diet. To estimate the sample size required for the study, we presumed (1) a population prevalence of nutritional failures of 20%, (2) a lower prevalence of nutritional failures after the intervention, and (3) a minimum difference of 20% after versus before the intervention. Based on the foregoing, and with power of the study set at 95% and the first-degree error at 0.05, 78 cases were required for the 2 groups. We enrolled 100 cases in each group to account for missing data.

To evaluate the mean daily weight increments before and after the intervention and to control for seasonal effects, we randomly sampled the files of 100 cases discharged in October, November and December 2001 (before the intervention), in 2002 (soon after the intervention) and in 2003 (more than 1 year after the intervention). The average admissions for each set of 3 months (2001, 2002 and 2003) was between 250 and 300 children. Using random number tables, we sampled 100 cases from each year. For each group of children, we computed the average length of stay in the unit and the average oedema-free weight gain at discharge. Diarrhoea and other symptoms were recorded daily, but feeds were not interrupted because of diarrhoea. No alternative feeds were available. Daily weight increment was computed for patients with marasmus by subtracting the discharge weight from the admission weight and dividing the result by the number of days in care. To determine the oedema-free weight gain, for all cases with oedema greater than 1+, we computed the increment between the lowest weight reached in the unit and the weight at discharge. Means and 95% confidence intervals are reported. Differences among means were evaluated by a multivariate analysis of variance model and controlling for possible confounding variables. The main outcome variable was the oedema-free daily weight gain of children before and after the intervention, adjusted for age at admission and length of treatment (days) in the hospital. Additional outcome variables were obtained for the period between January 2002 to December 2004 (3 years) based on hospital statistics: number of cases cured/total admissions for each month, number of cases dead/total admissions for each month and number of cases lost/total admissions for each month. These variables were adjusted for the total number of cases admitted in the same period. Cured means discharged when the 85% weight-for-length was attained, and there was no oedema. Lost indicates children removed from the hospital by the family, frequently because of lack of improvement. Mortality statistics were obtained retrospectively from the hospital database and prospectively from the nutrition ward medical records.

TABLE 1. *Contents of one 150-g serving of nutricam*

Ingredients	g	Energy units (kJ)	Proteins (g)	Fat (g)	Carbohydrates	Iron (mg)	Zinc (mg)
Cereal flour (maize, rice or millet)	20	64.8 (274)	1.4	0.6	13.3	0.5	0.1
Fish, meat, poultry or beans	10	20.0 (84.2)	2.4	0.6		0.2	0.2
Peanut butter	5	29.2 (121)	0.2	2.5	0.5	0.1	0.3
Vegetable oil	5	45.0 (185)	0	5			
Water	up to 150	0					
Total		159 (664.8)	4.0	8.7	13.7	0.8	0.6

The Ethics and Research Committee of Lacor Hospital approved the study.

Baseline Nutritional Procedures

Children admitted to the hospital were fed the F75 starter milk (75 energy units/100 mL, 314 J) in the amount of 135 mL/kg of body weight per 24 hours every 3 hours during the early phase of nutritional rehabilitation, and then the F100 formula (100 energy units/100 mL, 418 J; 135–200 mL/kg body weight per 24 hours) during the catch-up phase. This formula contained a complete micronutrient mixture (see reference (5), appendix 3).

New Nutritional Intervention

Using locally available ingredients, we prepared a semisolid porridge containing cereal flour as source of carbohydrates (corn 4 times/wk, rice twice and millet once), proteins (local dried fish 4 times/wk, chicken once, cow's meat once and beans once) and fat (always peanut butter and vegetable oil). We call the porridge "nutricam," cam in Acholi meaning food. A 150-g serving of nutricam made with 20 g flour (65 energy units, 274 J), 10 g fish, meat or dry legumes (20 energy units, 84 J), 5 g peanut butter (30 energy units, 122 J) and 5 g oil (45 energy units, 185 J), provides a total of 160 energy units (665 J) and 6.3 g proteins (Table 1). On average, 100 children per day per serving of 150 g of nutricam were prepared each morning and 100 g each afternoon.

Each child was offered two 150-g servings of nutricam each day in addition to the scheduled amount of milk. In this setting, it was not practical to dose the porridge according to body weight. Milk was administered according to body weight. Feeds were given under surveillance in a purposely built feeding hut, but we could not measure exactly the amount of food ingested. Most children consumed the whole feed within 1 hour after distribution.

Table 2 shows the amounts of ingredients for 200 servings of nutricam a day for 1 week. The monthly cost of nutricam (ingredients for 200 servings/d, fuel and salary of the cook) was €220. The porridge can be made at home as follows: (1) cook 2 tablespoons of maize flour (or millet or rice) in 1 cup of boiling water; (2) cook for about 15 minutes, then slowly add 1 tablespoon of powdered fish and one-half tablespoon of peanut butter, stir vigorously until a thick porridge is obtained; (3) add one-half tablespoon of vegetable oil to make the porridge more creamy. The source of protein can be fish, beef, poultry or beans, depending on availability.

RESULTS

No adverse reactions to nutricam were observed in the study. During the first 10 days of intervention, 36 oedematous children lost an average of 32 g/d until oedema disappeared. In 48 underweight children, there was a catch-up of 36 g/d (data not shown).

Weight Increments

Figure 2 shows the weight curves, in grams of body weight, of 20 children without oedema who received nutricam starting from the first week of August 2002. There was a conspicuous improvement in the slope of many weight curves compared with prenutricam values (Fig. 1). The average daily oedema-free weight gain was 21 g (range, 12–29 g) with milk alone in 2001, 35 g (range, 25–45 g) immediately after the intervention in 2002 and 59 g (range, 51–68 g) at the end of the first year of intervention 2003 (Fig. 3).

Table 3 shows the average increments in weight for each year of the study, corrected for days in care and age at admission (multivariate analysis). Days in care correlated with weight increments, but did not change significantly during treatment (an average of 20 days)

TABLE 2. *Ingredients used for 200 servings per day of nutricam for 1 week*

Day	Carbohydrates	Proteins	Fat
Monday	Maize (4 kg)	Dried fish (2 kg)	Peanut butter (1 kg) + oil (1 L)
Tuesday	Rice (5 kg)	Meat (2 kg)	Peanut butter (1 kg) + oil (1 L)
Wednesday	Millet (4 kg)	Dried fish (2 kg)	Peanut butter (1 kg) + oil (1 L)
Thursday	Maize (4 kg)	Chicken meat (2 kg)	Peanut butter (1 kg) + oil (1 L)
Friday	Rice (5 kg)	Dried fish (2 kg)	Peanut butter (1 kg) + oil (1 L)
Saturday	Maize (4 kg)	Beans (2 kg)	Peanut butter (1 kg) + oil (1 L)
Sunday	Maize (4 kg)	Peas (2 kg)	Peanut butter (1 kg) + oil (1 L)

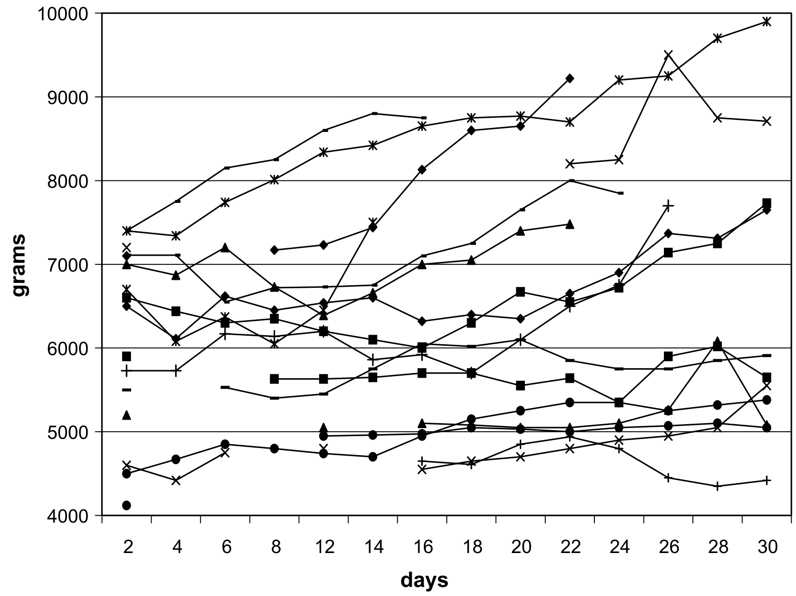

FIG. 2. Individual weight curves (weight in grams) during nutricam administration (August 2002).

increased from 525 g in 2001 (before nutricam) to 771 g in 2002 and 1274 g in 2003. Mean growth increments increased significantly as the study progressed (F = 38.0, $P < 0.0001$).

OUTCOME AND SURVIVAL

Figure 4 shows the numbers and trend of survival outcome as a percentage of cases admitted to the hospital each month. The top regression line shows the percentage of cases discharged as cured (ie, children who attained 85% weight-for-length), which increased from 54.5% (36/66 cases) in January 2002 to 93.3% (97/104 cases) in August 2004. The lower regression line shows the percentage of deaths and percentage of lost cases. Mortality and lost rates are considered collectively as overall failures; these were 45.5% (30/66 cases) in January 2002 and 6.7% (7/104 cases) in August 2004. The death rate was 21.2% (14/66 cases) in January 2002 versus 2.9% (3/104 cases) in August 2004. Table 4 shows the averages (and standard error) for each outcome variable (cure, death and lost-default) in the 3 years of the study after correction for the number of cases admitted in each study period (multivariate analysis). Again, the differences among the years are highly significant.

DISCUSSION

Nutricam plus milk was more effective than milk alone in nutritional rehabilitation of severely malnourished children. Oedema disappeared rapidly, and daily weight increments rose significantly compared with treatment with milk only. Nutricam did not affect the length of stay in the unit, probably because the children were severely ill and were affected by diseases typical

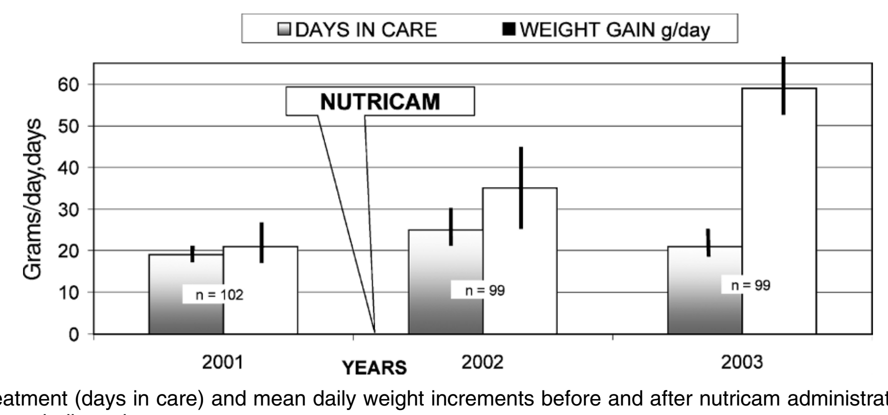

FIG. 3. Length of treatment (days in care) and mean daily weight increments before and after nutricam administration. Means and 95% confidence intervals are indicated.

TABLE 3. *Average weight gain: analysis of variance table*

Year	Mean weight gain (g)	Standard error	95% Confidence intervals Lower limit	Upper limit
2001	525	77.1	373	676
2002	771	78.0	618	925
2003	1274	78.0	1120	1427
Source of variation	Degrees of freedom	*F*	*P*	Partial ETA
Days in care	1	68.092	<0.0001	0.186
Age at entry	1	21.826	<0.0001	0.068
Year of study	2	24.057	<0.0001	0.139

F, variance ratio; Partial ETA, proportion of the total variability explained by the variable (effect size measure).

of African countries (diarrhoea, malaria, pneumonia, tuberculosis, etc) besides malnutrition.

The change observed over time in the outcome variables (increments in weight and survival) may not be entirely the result of the nutritional intervention. During the 2 years after the intervention started, various improvements were made in the nutritional rehabilitation unit, although the care of severely malnourished children remained unchanged. Moreover, the number and category of medical personnel in the nutrition unit did not change, and no additional motivation was given to medical personnel or caretakers/mothers to improve care. During the study, the number of admissions increased, and the status of the children at admission was worse, probably because warring factions had caused many families to abandon their villages. However, the disease pattern in these children and their management protocol did not differ from that of the other children studied.

Pretest and posttest human immunodeficiency virus (HIV) counseling was not routinely offered to all patients, and it was difficult to determine HIV prevalence among the children in the study. However, a cross-sectional investigation of patients in the same ward in 2004 showed an HIV prevalence of 10% (unpublished data). Therefore, it is unlikely that malnutrition in our study was HIV-related.

About 95.4% of African children have the C/C-13910 genotype of the lactase–phlorizin hydrolase gene that causes adult-type hypolactasia (vs 14.5% of Finnish children) (13). Ninety-one percent of the population of Sao Tome (West Africa) has lactose intolerance (14). As done in other studies (15), we identified cases of lactose malabsorption by testing reducing substances in the faeces. Diarrhoea is 1 of the main causes of fatality in severely malnourished children. Skim lactose-rich milk with added sugar is not the best treatment for malnourished children with diarrhoea (16,17), and international agencies recommend supplementary feeding (5). In this context, it is not surprising that milk alone is not the best treatment for severely malnourished children.

Nutricam is locally feasible at a low cost (about €0.056/serving, including labour and fuel). It is accepted by the local population, easy to prepare and

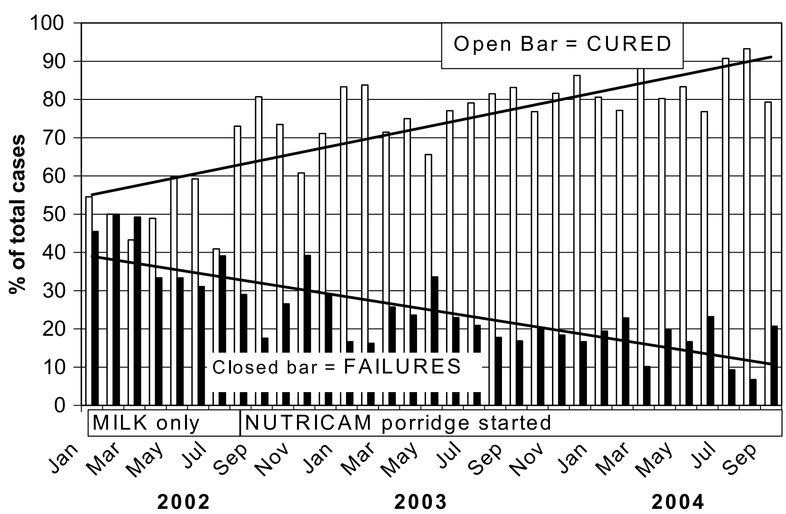

FIG. 4. Outcome of nutritional rehabilitation before and after nutricam administration. The numbers and trends (regression line) of survival outcome are shown as percentage of cases admitted to the hospital each month. The top regression line refers to cases discharged as cured (ie, children above 85% weight-for-length). The lower regression line refers to overall failures (dead and lost cases).

TABLE 4. *Outcome at the nutritional unit over time*

Year	% Cured	% Dead	% Defaulters
2002	59.6 (3.7)	17.0 (1.2)	18.2 (2.1)
2003	78.7 (1.7)	10.2 (0.9)	10.5 (1.3)
2004	83.5 (2.0)	9.2 (1.5)	3.7 (1.2)
Analysis of variance	$F = 21.2$, $P < 0.0001$	$F = 12.5$, $P < 0.0001$	$F = 10.9$, $P < 0.0001$

Values are expressed as standard error.
F, variance ratio.

effective for nutritional rehabilitation. Nutricam was not intended to supply all of the daily energy requirements, but is well suited as a supplement to mother's milk. At the nutritional unit, mothers/caretakers are offered nutritional education twice daily by the health educator, and they participate in the preparation of nutricam for at least 5 days before their children are discharged from the hospital.

Nutritional failures decreased by more than 50% after nutricam. From August 2002 to September 2004, we estimated that 454 children were saved from nutritional failure: 216 fewer deaths and 238 fewer patients lost to treatment versus the period from January to July 2002.

This study demonstrates the efficacy of supplemental feeding with a varied protein source for severely malnourished children. The comparison of an untreated cohort with a different treated cohort could be seen as a limitation of our study. However, we could not divide each cohort into milk-only and milk-plus-nutricam subgroups because the children were severely malnourished and in need of supplementation.

This intervention did not require a special project or sponsors, just 1 person at a cost of only €220/mo for the entire action. The hospital management continued this intervention, which was also implemented in 3 district hospitals in the region. It costs about €3000 to build the kitchen and purchase equipment for each new therapeutic feeding centre. The cost of providing powdered milk by international agencies is €32,370/yr for the same group of children who entered our study. The results of nutritional rehabilitation with milk alone are often disappointing. Moreover, milk is not always available out of the hospital, which means that many children relapse. The widespread use of the porridge together with milk, which resulted in better outcomes than milk alone, could produce a savings thus releasing resources for other uses.

Lastly, nutritional rehabilitation is essential to survival for the many children with malnutrition in developing countries (5), but it cannot be based solely on powdered milk. The Lacor study highlights the need to involve local communities in the selection of locally available nutritious foods for children to prevent and treat malnutrition.

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